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Report WO-32



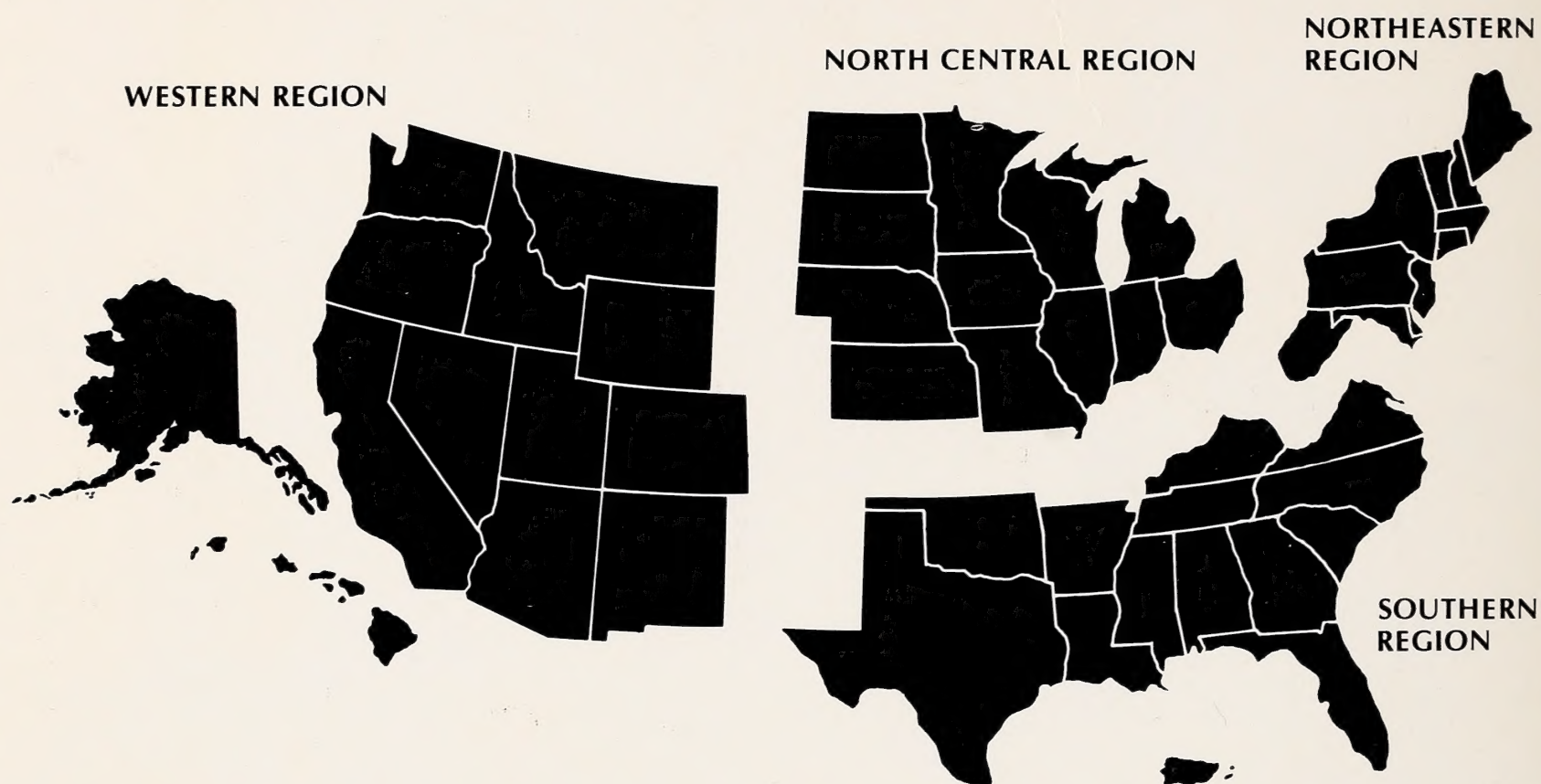
1980-1990 National Program of Research for Forests and Associated Rangelands

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CURRENT SERIAL RECORDS

Planning Regions for Forestry and Associated Rangeland Research



U.S. Department of Agriculture, Forest Service

Association of State College and University
Forestry Research Organizations

U.S. Department of Agriculture, Cooperative State Research Service

May 1982

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Foreword

Managers of research programs in the USDA Forest Service, forestry schools and universities, and State Agricultural Experiment Stations must decide which environmental problems warrant long-term investment of limited scientific brainpower and budgets. The goal is to develop technology—in the form of knowledge, methods, or equipment—that will increase productivity on forests and associated rangelands while protecting environmental values. This publication describes the current and projected research programs of the USDA Forest Service and 60 forestry schools.

The USDA Forest Service research programs described here involve the development of new technology needed for public land management, State and other agencies, various private organizations, the small-woodland owner, and individual private citizens including the urban dweller—all forest users.

The USDA Cooperative State Research Service/University research program in this document is aimed at graduate-level education of scientists who, when employed by Federal and State agencies, universities, and industries, will continue to provide advances in needed research. Within the university community, integrated efforts are directed toward the use of research findings in the education of students, practicing professionals, and the general public through extension of research findings.

From a USDA Forest Service research perspective, this publication fulfills the requirements of the Resources Planning Act (RPA) of 1974, and is intended as a companion piece to the current RPA document titled "A Recommended Renewable Resources Program—1980 Update" (U.S. Department of Agriculture, Forest Service 1980). Page 18 of that document describes how the Research programs of RPA" . . . will be explained in detail in the separate publication at a later date." This is that "separate publication."

And from a university standpoint, this publication provides an updated guide for long-range planning in the USDA Cooperative State Research Service and the participating forestry schools as required by Title XIV of the Food and Agricultural Act of 1977.

Readers who wish to explore these research programs more fully—to comment on them, to help shape them, to participate in and cooperate with them—are urged to contact the organizations listed at the end of each section of this publication.

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It is remarkable what a value is still put upon wood even in this age and in this new country, a value more permanent and universal than that of gold. After all our discoveries and inventions, no man will go by a pile of wood. It is as precious to us as it was to our Saxon and Norman ancestors.

Henry David Thoreau
"The Illustrated Walden"
Princeton University Press
Princeton, New Jersey, 1973

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Summary

Forest technology—knowledge, methodology, and equipment—is the product of research, and constitutes the major longrun influence on forest productivity. The kinds of technology that eventually emerge from research depend on the research goals that are selected, and the mix of research programs to accomplish those goals. This report describes the forestry research goals and program areas of the 60 forestry schools and universities, and the U.S. Department of Agriculture (USDA). Information presented here reflects the thinking of a broad segment of the forest science community about America's research needs for forests and associated rangelands.

In the sense that many national forestry research problems can be fully understood and addressed only in their national context, we have many "national" problems. But there are few national solutions. Most of the research required to deal with important problems of forests and associated rangelands must be undertaken at the regional and local levels—within a national context.

In that regard, future research goals for four broad geographic regions of the country (as shown on the inside front cover), and the USDA Forest Service Forest Products Laboratory (FPL) at Madison, Wisconsin, are as follows:

Western Region

- Improve forest land productivity and protection
- Increase rangeland productivity
- Enhance water yield and quality
- Improve integrated pest management techniques
- Increase energy production
- Enhance wilderness values and opportunities for recreation

North Central Region

- Improve forest regeneration, growth, yield, and composition
- Discover new ways to remove, process, and market harvested trees
- Improve techniques for management of insects, diseases, and wildfires
- Create new forest inventory methods and procedures to evaluate alternative forest investment strategies
- Improve the quality of life through the use of urban and rural resources

Southern Region

- Develop integrated pest management techniques
- Improve vegetation management procedures
- Produce better regeneration techniques for southern forests
- Increase forest land productivity
- Devise ways to use wood for energy

Northeastern Region

- Increase understanding of the amount, quality, and availability of the eastern hardwood resource
- Improve utilization, harvesting, and marketing techniques for low-quality hardwoods
- Increase supply of wood fiber for energy production
- Enhance management, use, and productivity of forest lands
- Develop methods to evaluate multiple-use potential of land
- Find substitutes for chemical forest pesticides
- Consolidate control techniques to manage insect populations
- Devise ways to reduce disease and decay in trees through silvicultural, biological, genetic, and chemical methods
- Improve mineland reclamation measures
- Increase understanding of effects of atmospheric deposition and how forests can help ameliorate the problem
- Develop ways to increase the availability of outdoor recreation opportunities

Forest Products Laboratory (FPL)

- Optimize material properties of wood
- Improve production of wood-based chemicals
- Extend timber supplies through improved processing
- Improve structural applications of wood
- Improve ways to utilize residues and recycled fiber
- Reduce energy consumption through improvements in utilization technology

Some goals are similar for all regions; other goals are uniquely related to the physical and social characteristics of a given region.

To meet these various goals the combined university-USDA research effort is outlined in scientist years (SY's) for the base year 1980, with projections for 1985 and 1990. A scientist year includes all technical and clerical support, together with facility, administrative, and other operational costs necessary to support one scientist for 1 year. A scientist employed by the Federal Government is defined as one who holds a grade of GS-11 or higher. A university scientist is considered to hold the rank of an assistant professor or above.

The SY's are allocated among seven research program areas, each encompassing two or three research problems as follows:

Multiresource Inventory, Appraisal, and Evaluation

- Multiresource inventory and appraisal
- Alternative uses of land
- Multiple-use potential and evaluation

Timber Management

- Biology, culture, and management of forests and timber-related crops
- Genetics and breeding of forest trees
- Economics of timber production

Forest Protection

- Control of insects affecting forests
- Control of diseases, parasites, and nematodes affecting forests
- Prevention and control of forest and range fires

Harvesting, Processing, and Marketing of Wood Products

- Harvesting and forest engineering systems
- Properties, processing, and protection of wood
- Economics and marketing of wood products

Forest Watersheds, Soils, and Pollution

- Watershed protection and management
- Soil, plant, water, and nutrient relationships
- Alleviation of soil, water, and air pollution

Forest Range, Wildlife, and Fisheries Habitat Development

- Management of range resources
- Wildlife and fish habitat

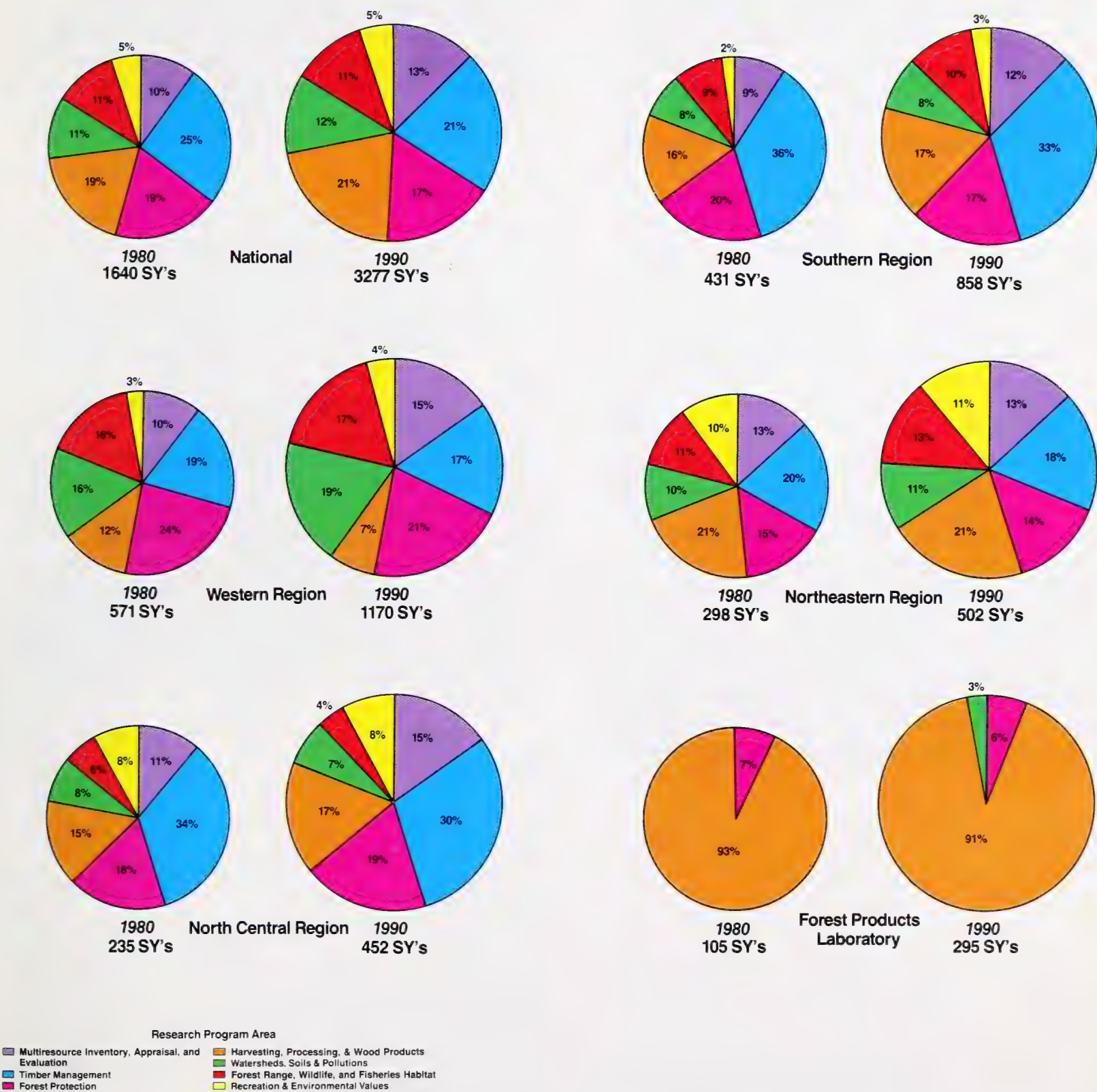
Forest Recreation and Environmental Values

- Outdoor recreation
- Rural and urban environmental enhancement

The total number of SY's for forest and associated rangeland research for USDA Forest Service, State Agricultural Experiment Stations, and forestry schools in 1980 was 1640. By 1990 the number of SY's required to accommodate regional research goals would total 3277. Those increases in SY's would shift within research program areas as shown in the following graphs.

This report does not reflect the total research effort that is needed on problems related to forests and associated rangelands. Only research conducted by the USDA and Land-Grant Universities and State Colleges is listed. Various other State and Federal agencies and private organizations conduct forest and associated rangeland research. How much is not precisely known, but the total may equal the research described in this report.

Program of Research For Forests and Associated Rangelands



Introduction

Forest and range resources will make increasingly important contributions to the quality of American life in the decades ahead. This report—the result of continuing national and regional planning efforts by forestry schools at universities, and the U.S. Department of Agriculture (USDA)—describes the current and projected research program for improving the contributions of this Nation's forest and range resources to American society.

This report is not the first coordinated planning effort for forestry research. The last such effort was published in 1978 as the "National Program of Research for Forests and Rangelands" (Anonymous 1978). The present report is an update of that publication and provides a current estimate of the scientific efforts required—within the university community and USDA Forest Service—for attacking various forestry and range research problem areas for the period 1980-90.

This report provides an updated basis for the research portion of the 1980-85 program under the 1974 Renewable Resources Planning Act of the USDA Forest Service. And it provides a current guide for long-range forest research planning in the USDA Cooperative State Research Service (CSRS), and the 60 participating forestry schools as required by Title XIV of the Food and Agricultural Act of 1977.

Background

In 1974, Congress passed the Forest and Rangeland Renewable Resources Planning Act. This law was subsequently amended and expanded by the National Forest Management Act of 1976.

The Resources Planning Act, also known as RPA, provides a framework for making decisions about managing and using forests, rangelands, and their associated waters for the long-term benefit of society, the economy, and the environment. RPA directs the Secretary of Agriculture to prepare two documents to facilitate this planning:

1. A Renewable Resource Assessment. This assessment was first prepared in 1975 and updated in 1979. In the future it will be updated at 10-year intervals. The assessment provides the facts and figures on supply and demand for use in developing long-range policies and programs for renewable resources.

2. A Renewable Resource Program. This document was first prepared in 1975, and updated in 1980—"A Recommended Renewable Resources Program—1980 Update" (U.S. Department of Agriculture, Forest Service 1980). Future updates are due every 5 years. The program guides Forest Service program planning and activities for management of the National Forest system; cooperative assistance to States and private landowners; and research to improve the condition, productivity, and use of our forests and rangelands. That updated program document indicated that the

research aspects of RPA would "be explained in detail in a separate publication at a later date." This report is that "separate publication."

The Forest Service portion of this report is in terms of an RPA research program designed to provide new technology at an accelerated pace—an increase of about 113 percent over the next decade in terms of number of scientists involved.

The actual levels of Forest Service research effort each year will be determined through the annual budget process—which includes additional analyses of costs and benefits of new forest technology in light of other national priorities.

The CSRS-university portion of this research program aims for approximately an 81 percent increase in number of scientists over the next decade. An important element of this process is graduate-level education of scientists who, when employed by Federal and State agencies, universities, and industries, will continue to provide advances in needed research. Within the university community, efforts are directed toward the use of research findings in the education of students, practicing professionals, and the general public through extension of research findings.

The actual level of research within the university community is determined by appropriations both at the Federal level under McIntire-Stennis legislation and at the State level, where appropriated funding is provided through agricultural experiment stations and to State-supported forestry schools not part of the agricultural experiment station system. Cooperative aids, grants, contracts, and endowments also are an important element of university research funding.

Research Orientation

In the years ahead, we expect the demand for the resources produced on forest and rangeland (forage, recreation, timber, water, wilderness, and wildlife) to continue to grow rapidly. But if recent management trends continue, the supply of these resources will increase at a slower pace.

Myriad Opportunities

There are many opportunities to extend and increase supplies of nearly all renewable resource products on the 1.7 billion acres of forest and rangeland and associated waters. For example, improving public access by constructing trails or boat landings, and dispersing visitors to underutilized areas can greatly expand recreational opportunities. There is also a large potential for extending timber supplies through increased efficiency in processing, manufacturing, and construction.

Through improved regeneration, control of tree spacing and species composition, improved harvesting practices, fertilization, and other management measures, timber supplies can be more than doubled. Under intensive management, forest and rangelands can support nearly three times the present level of range grazing. In addition, they could support much larger numbers of most species of wildlife. America's waters also have the potential to support larger populations of fish and wildlife. Water yield and quality can be substantially increased.

Research can provide the technology to improve the management and the use of forest and range resources, and to minimize potential adverse environmental effects of such management and use. Research efforts need to be expanded in high-priority problem areas. These include improving wood utilization; developing more intensive forest management

practices to increase the Nation's timber supply and to provide biomass for energy; providing the new knowledge necessary to address current and anticipated environmental issues (e.g., range utilization, arid land problems, and wildlife management); and increasing the land manager's stewardship capabilities in areas such as protection and pollution control.

The proposed research program is designed to

- Respond to changing needs—primarily national, regional, or specific needs for which technology is inadequate.
- Contribute to productivity, foreign exchange, and other benefits—including both quantifiable and non-quantifiable results.
- Respond to national policies—particularly those delineated by the executive and legislative branches of the Federal Government.

Respond to Changing Needs

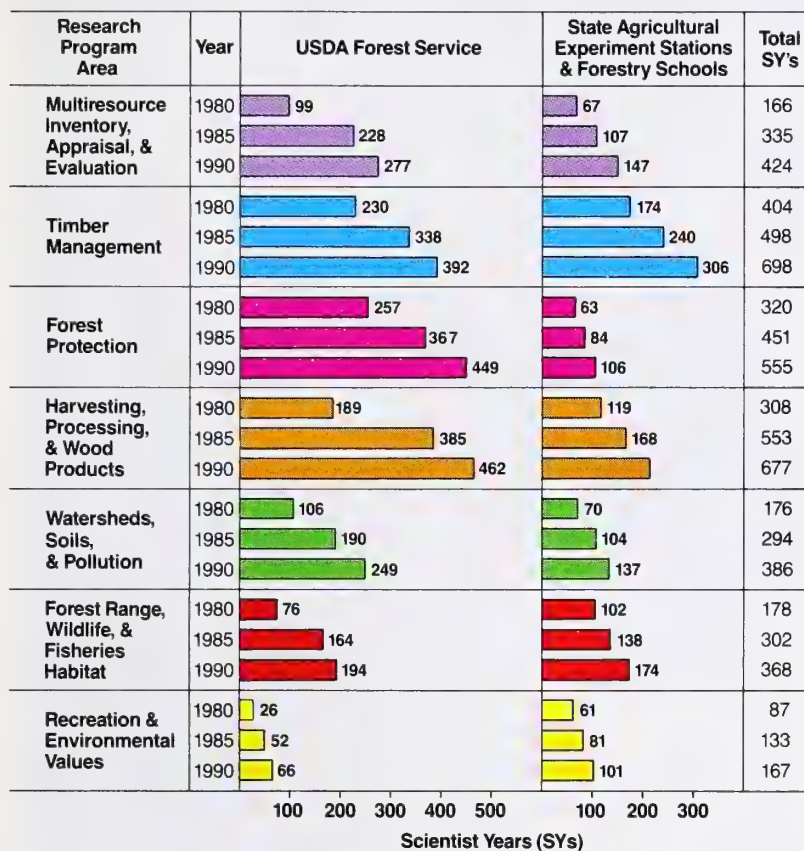
Needs for forestry research are generated by a vast number and variety of clients. An estimated 48,000 professionals in 42 diverse disciplines, employed by more than 40 agencies, constitute the Federal clients for forestry research. Furthermore, an estimated 200,000 of America's resource professionals also use forestry research results. Private landowners, resource-dependent industries, educators and students, legislators, citizen groups, homeowners, and the general public add inestimable numbers to the long list of clients for the results of forestry research (Callaham 1981).

Contribute to Productivity

Contributions to productivity and other returns to society from research have been repeatedly demonstrated. Improvements in technology resulting from research and development contribute 30 to 70 percent of the growth in a nation's productivity. However, growth in productivity in the United States has slowed in recent years, and certain studies suggest that declining investment in R&D, particularly in basic research, is a significant cause. Our decline in productivity contrasts sharply with growth in productivity of other developed countries where significantly larger investments have been made in R&D programs (Callaham 1981).

National

Scientist Years (SY's) For Forestry and Associated Rangelands Research For State Agricultural Experiment Stations and Forestry Schools, and USDA Forest Service For 1980, 1985 and 1990



Internal rates of return from several areas of agricultural research are in the 30- to 40-percent range. Considering such rates of return versus the relatively low current expenditures for research, economists have argued strongly that we are underinvesting in agricultural and forestry research (Ruttan 1978). Although internal rates of return from forestry research have not been carefully estimated, economists anticipate that such returns will parallel those from agricultural research.

Respond to National Policy

National policy on science and technology influences the direction and magnitude of forestry research. Such policy emphasizes that there is a tremendous need for facts and incontrovertible data as a basis for decisionmaking, and that every major department of government should support enough science to assure the quality of the technology it uses (Callahan 1981).

Regional Emphasis

In the sense that many forestry research problems can be fully understood and addressed only in their national context, we have many "national" problems. But there are few national solutions. Most of the research required to deal with important problems of forests and associated rangelands must be undertaken at the regional level—within a national context. Therefore, future research needs and programs in this report are stratified into four regions (as shown on the inside front cover), plus the Forest Service Forest Products Laboratory at Madison, Wisconsin.

The Western Region

The Area

The Western Region, as designated for this planning purpose, encompasses 13 States, including Alaska and Hawaii. The region comprises slightly more than 19 percent of our population, 49 percent of our total land area, 63 percent of the total forest and rangeland area, and 26 percent of the commercial forest land. There are about 23 acres of forests and associated rangelands per person, compared with a national average of about 7 acres.

The land area classified as forests and rangelands is about 1 billion acres. These lands include well-stocked forest areas, treeless grasslands, tundras, deserts, and shrublands.

Public ownership of forests and associated rangelands plays a major role in the West. Of the 127 million acres of commercial forest land in the region, nearly 70 percent is publicly owned. Most of this land is in Federal ownership. Forest-range is mostly in Federal ownership, with only about 31 percent in other ownerships.

Forests and rangelands of the region produce valuable food and fiber. Forests are major producers of lumber, plywood, pulp and paper, and other forest products. Rangelands produce millions of animal unit months¹ of grazing for the livestock industry. In total, forest and associated rangeland resources generate thousands of full-and part-time jobs.

Water is yet another highly valuable resource of the region's forests and associated rangelands. Since much of the region is arid to semihumid, water is inexorably linked to the management and use of forest and rangeland resources. The importance of water continues to grow for domestic, agricultural, and industrial uses, and for hydroelectric power.

The region's forests and associated rangelands also have the habitats necessary for the survival of numerous endangered and threatened species of wildlife and plants. Among these are the grizzly bear, the bald eagle, and other bird species, including many located in California's deserts and in the Pacific Islands. In addition, the region provides prime habitat for popular big game, upland game birds, fresh- and saltwater game fish, and many nongame species.

Finally, forest and associated rangeland resources play a significant role in the outdoor activities of our

citizens. Although the West contains less than one-fifth of America's population, it contains a major portion of the public recreational lands for both developed and wilderness recreation. Recreation use continues to increase annually as millions of visitors from throughout the Nation are attracted to the region.

The demands for goods and services from the western forests and rangelands have been growing rapidly. National and regional projections indicate a continuation of rapid growth in the decades ahead. As demands grow and efforts to increase output of some products constrain or reduce the output of others, conflicts among users will intensify. The resolution of these conflicts will depend in part on more complete understanding of the interactions among product outputs that result from management actions.

Scope of Research

The forests and associated rangelands in the West provide lumber, pulp, and other wood products, water, livestock forage, wildlife habitat, and a variety of recreational experiences. However, a finite land base, expanding population, growing national economy, and increased environmental awareness on the part of the American public have produced a host of conflicts and perplexing questions about the management and use of forests and associated rangelands for multiple purposes. Since resource managers can manipulate the output levels of various products, how do we decide which management alternatives will yield maximum benefits for the general public? Forest and rangeland resource managers and landowners need better information to accommodate the complex challenge of multiple resource management.

Multiresource inventory techniques must be developed for evaluating the current and potential status of the region's forests and associated rangelands. We also need techniques for displaying these resource data and evaluating effects of various management alternatives.

Increasing demands for wood and fiber will require new methods for the establishment, culture, and harvesting of timber and related crops for commodity uses. Research is designed to increase timber and wood fiber production through better reforestation, stand culture, control of competing vegetation, and improved soil quality. Genetic improvement of forest trees must be accelerated to improve quality, resistance to insects and diseases, and growth rate.

¹An animal unit month is the amount of forage required by a 1,000-lb cow or its equivalent in 1 month.



*Above
Watershed research addresses erosion and sediment production, channel stabilization, and the influence of forest management practices on water yield, regimen, and quality.*

*Right
Scientists study the impacts of recreationists on wilderness environments.*

Fire, insects, and disease have a significant impact on forest resources: mortality and loss of growth equal a sizable portion of the annual harvest. Forest insect and disease research stresses the development of protective measures that integrate silvicultural practices with chemical and biological controls. Fire researchers determine basic fire behavior and fire effects, develop ecologically sound and economically efficient fire management and control techniques, and develop methods for managing air resources.





*Above and above right
Fire researchers develop chemical retardants and
drop-control systems to knock down and control
fires.*



One way to extend our wood supply is to learn how to use it more efficiently. Research toward this end ranges from developing better, more waste-free harvesting systems to finding new ways to protect wood in use. Additional research is needed to cover the spectrum from basic studies on wood properties to practical improvements in manufacturing techniques, including the conversion of waste wood into marketable products.

All major rivers of the West have their origins in the forested mountains. These rivers furnish irrigation, hydroelectric power, and drinking water for western agriculture, industry, and communities. Watershed research addresses erosion and sediment production, channel stabilization, and the influence of forest management practices on water yield, regimen, and quality.

Habitat needs of wildlife and fish on forest and rangeland often conflict with and complicate management for other uses such as domestic livestock grazing and recreation. Resource management practices to protect, rehabilitate, and enhance habitats will be sought. Special management techniques will be developed to maintain habitat for threatened or endangered species of animals and plants.



A fisheries biologist collects streambed samples in studies to reduce sediment and improve water quality for fish habitat.

The public has a new awareness of the many values of our rangelands. Environmentalists and recreationists demand use of rangelands, improved management by all users, and a voice in the decisionmaking process affecting their interests. The livestock industry is interested in improved management of the rangeland resource that will protect all values and provide a firm foundation for continued growth.

Recreation use of forests and associated rangelands of the western region has doubled in the past decade with increased damage to some resources. Research is needed to improve techniques for projecting demand for various types of recreation, for estimating costs and benefits, and for locating and managing recreation activities. Reduction of adverse impacts of recreation use will be addressed.

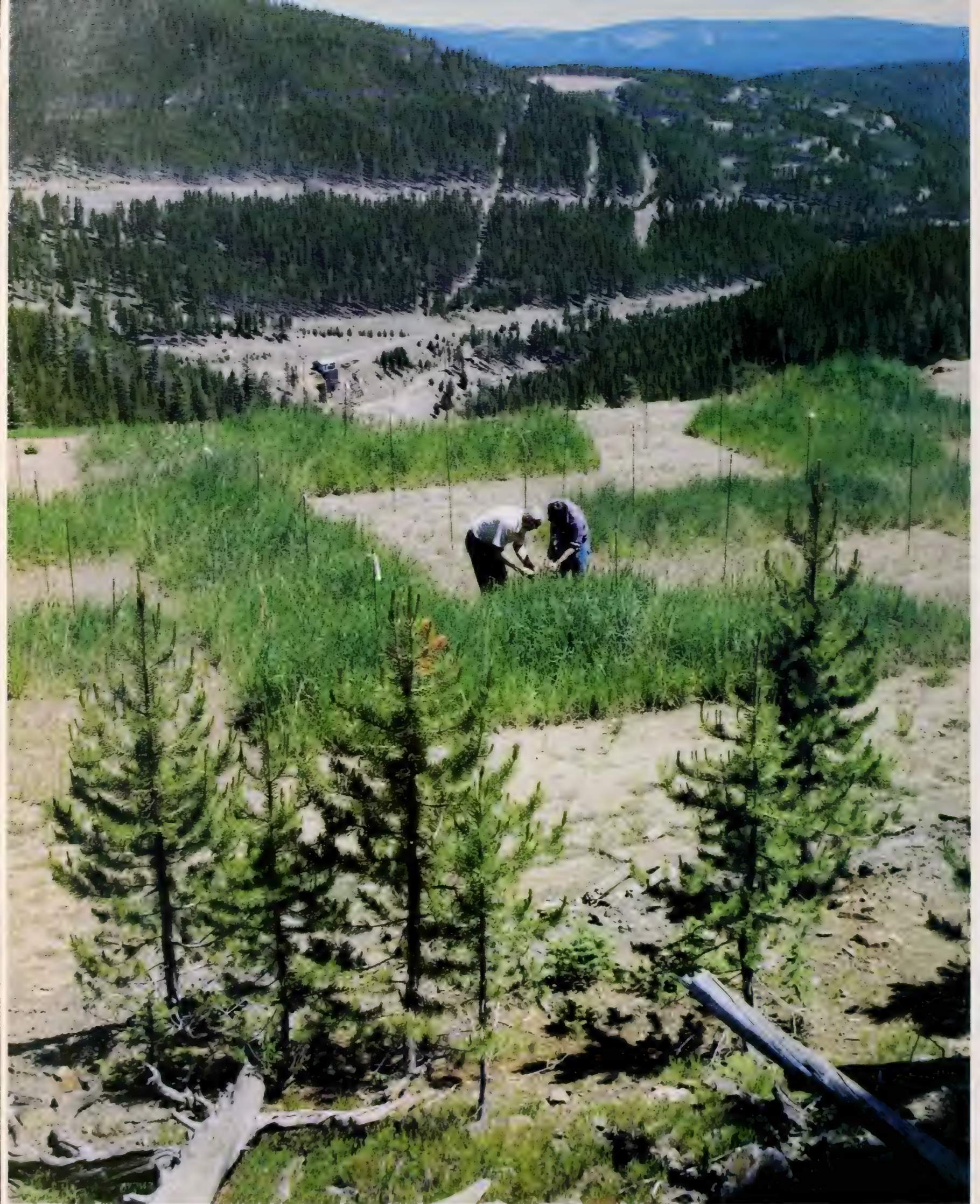
Energy requirements have focused increased attention on recovery of energy minerals and woody biomass. Research is needed to minimize the adverse impacts of mining through rehabilitation and management. Similarly, research is needed on inventory, recovery, and production of wood residue for energy and on the environmental impacts of residue removal.

Areas of Emphasis

- Develop new techniques for improving forest land management and production.—Pressure to improve the productivity of America's forest lands will continue to increase because of a shrinking forest land base, increasing demands, and rising prices for wood. Increased productivity is needed to minimize costs to consumers as well as meet national needs in future years. Timber productivity in the West could be improved within environmental and social constraints if new technology is developed by research and applied by resource managers.

Improved multiresource inventory techniques will be developed to better identify land productivity and resource management opportunities. Measures to maintain or improve forest soil fertility and establishment of most productive stocking levels will be addressed. Better methods to regenerate nonstocked sites and other planted and natural stands. Improved techniques of intensive forest management to benefit wildlife and other forest values will also be developed.

Important research needs include improvements in harvesting, processing, new product development, and utilization systems for both green and dead timber.



Soil scientists are developing revegetation techniques for reclamation of mined lands.



*Above and above right
Scientists conduct experiments on forestry smoke
management.*



- Develop management practices that will improve water yield and quality.— Western forests and rangelands are extremely important sources of water for meeting downstream needs. As custodial management of forests and rangelands changes to intensive management for a variety of goods and services, water resources are impacted by more development, more roads, and greater population pressures.

Western agriculture, industry, and the general way of life are greatly dependent on local water sources, and water limits development opportunities.

Research should develop improved techniques to alleviate the impacts of pollutants from forest and range management activities. Hydrologic and engineering problems of steep slopes, erosive soils, and heavily used riparian zones should be addressed. Other priority needs include reduction of sediment problems to increase water quality and fisheries production from western watersheds, and evaluation of the effects of various management strategies and practices on water yield and quality.

- Develop new techniques for improving rangeland management and productivity.—Improvement is needed to make extensive areas of rangeland in the West more productive. User demands on the many resources of rangelands are rapidly increasing and frequently conflicting. The relative importance of rangelands for livestock production is increasing.

Rangeland research is urgently needed to provide scientific support for technical land management programs that have increased dramatically over the last decade. Substantial increases in livestock, wildlife (including threatened and endangered species), recreation, and water production capacity can be obtained through research on improved management and rehabilitation practices.

- Develop integrated pest management techniques.—Insects, diseases, weeds, and vertebrate pests have a significant impact on the Nation's forest and rangeland resources. Forest growth losses can be as high as one-fifth the annual growth in some regions. In western forests, bark beetles have been a major cause of timber mortality, but recent outbreaks of tussock moth and spruce budworm also have been highly destructive. Foremost among diseases causing losses in western forests are dwarf mistletoes, root rots, and white pine blister rust. Vertebrate pests such as deer and pocket gophers also cause serious damage to forest regeneration. Combinations of two or more pests may be responsible for some mortality. Valuable rangelands and wildlife shrub areas are also affected by pest problems.



Top
Range scientists are determining the best way to manage sites for deer, livestock, and timber, and to estimate long-term effects of allowing cattle to graze in high-mountain meadows.

Above
Weir measuring runoff from a research watershed in a ponderosa pine forest. (Photo courtesy of the University of Arizona.)

Western Region

Scientist Years (SY's) For Forestry and Associated Rangelands Research
For State Agricultural Experiment Stations and Forestry Schools,
and USDA Forest Service For 1980, 1985 and 1990

Research Program Area	Year	USDA Forest Service	State Agricultural Experiment Stations & Forestry Schools	Total SY's
Multiresource Inventory, Appraisal, & Evaluation	1980	44	19	63
	1985	119	30	149
	1990	140	42	182
Timber Management	1980	71	39	110
	1985	110	52	163
	1990	132	67	199
Forest Protection	1980	127	14	141
	1985	176	19	195
	1990	211	24	235
Harvesting, Processing, & Wood Products	1980	16	28	44
	1985	36	36	72
	1990	41	43	84
Watersheds, Soils, & Pollution	1980	70	22	92
	1985	131	36	167
	1990	174	49	223
Forest Range, Wildlife, & Fisheries Habitat	1980	50	43	93
	1985	107	57	164
	1990	124	71	194
Recreation & Environmental Values	1980	8	19	27
	1985	22	24	46
	1990	23	29	52

50 100 150 200 250 50 100 150
Scientist Years (SY's)

In view of anticipated critical resource shortages, pest research should focus on minimizing the losses caused by the destructive, but natural, components of the forest and rangeland environments. Research should develop preventive measures based on sound silvicultural and range management practices integrated with chemical and/or biological control methods. We need improved techniques to detect, evaluate, and predict pest damage levels on forests and rangeland resources as soon as possible. Strong and immediate needs for multidisciplinary research should receive greater attention.

- Improve energy production.—Millions of acres of the western region's forests and rangelands are underlain with coal and other minerals. With today's energy market, we anticipate that exploration and development will proceed rapidly. Additional information is needed quickly to evaluate the effects of mineral exploitation and surface mining, and to minimize the adverse impacts of mining through rehabilitation and management. Additional research is needed on revegetation techniques in critical areas such as arid, semiarid, alpine sites, highly acid soils, and aquatic habitats. To develop alternate methods of mining and reclamation, we need to sponsor hydrology and engineering studies.

The burgeoning use of wood for energy is likely to reach 5 quads² in 5 to 10 years—up from about 1-1/2 quads today. Much of the forest biomass available for energy production is located in the West. Power plant plans and actual construction are already underway to use more wood. Special research efforts are needed to develop technology to inventory, recover, and maximize production of woody biomass fuels within environmental constraints. Studies are also needed on the environmental impacts of removing green and dead residues from western forests and rangelands.

- Increase understanding of recreation and wilderness values.—Western forest resources play a key role in supporting the region's travel and tourism industry. Research must develop management techniques capable of protecting the resource while it sustains high levels of recreational use. Research is also needed to develop management techniques to integrate non-commodity forest land uses with commodity uses, such as timber harvesting.

Institutions in the Western Region Forest Resources Planning Group

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University of Alaska
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Missoula, Montana 59801

University of Arizona
Tucson, Arizona 85721

University of Nevada
Reno, Nevada 89507

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Pacific Southwest Forest and
Range Experiment Station
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Berkeley, California 94701

Pacific Northwest Forest
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809 N.E. 6th Avenue
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Rocky Mountain Forest
and Range Experiment Station
240 West Prospect Street
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²A quad is 10¹⁵ Btu.

The North Central Region

The Area

The North Central Region includes three distinct subregions: the Plains States (Kansas, Nebraska, South Dakota, North Dakota), the Lake States (Minnesota, Michigan, and Wisconsin), and the Central States (Missouri, Iowa, Illinois, Indiana, and Ohio). From the planted shelterbelts of the northern Great Plains to the lake-dotted forests and bogs of Minnesota to the Ozark glades, these three subregions are distinguished by their forest resources and by demographic, economic, and social features.

The region contains 27 percent of the Nation's population, 10 percent of its total forest land, and 16 percent of its commercial forest land. Forest land/population ratios range from 3 acres per person in the Lake States to slightly more than 1 acre in the Plains States.

Of the 78 million acres of commercial forest land in the North Central States, almost three-fourths is privately owned. Over the region, about 39 percent of the public forests are federally owned. Nearly half of all State- and county-owned commercial forest land in the entire Nation is located in the Lake States.

Primarily hardwood country, the North Central States have a fifth of our net volume of hardwood growing stock and 3 percent of the softwood. Within the region, 64 percent of the hardwood and 86 percent of the softwood grows in the Lake States. The region produces about 19 percent of America's hardwood growth and almost a fourth of its hardwood harvest.

Pulp and paper lead all other forest industries in the region in terms of volume of wood used and value added. Fine hardwoods for lumber and veneer are also important in the Central and Lake States. In 1977, the region produced 998 million cubic feet of roundwood products. Forest industries generate thousands of full- and part-time jobs and annually add more than \$5 billion to the economy of the North Central Region.

The region's forests provide a place for leisure as well as for work. Thousands of people enjoy more than 15 million acres of State, county, and municipal parks and forests. National Parks and Forests provide the region's most extensive forest and lake landscapes and the largest wilderness area in the Eastern United States. A wide variety of recreational activities is also pursued on private, industrial, State, and county lands.

The region's rangelands are among our most productive. Management strategies are needed to protect and enhance the productivity and condition of this important resource.

As urbanization increases and energy becomes scarcer, urban residents are less likely to travel far from home for relaxation, nature study, or other forms of recreation. Therefore, better strategies are needed for managing urban forest resources to enrich the lives of city dwellers.

The North Central Region has the habitats necessary for the survival of several threatened or endangered species of wildlife, including the bald eagle, the eastern timber wolf, the Indiana bat, the Kirtland's warbler, the blackfooted ferret, the swift fox, and the peregrine falcon. In addition, forests provide prime habitat for game species such as deer, moose, and ruffed grouse, and for many nongame birds and animals. Agricultural areas shelter pheasants, rabbits, and woodcock in the winter.

Demands on the forest for nontimber uses are increasing, the forest land base is shrinking, and energy problems are growing. Forest lands continue to be converted to nonforest uses: pasture, agricultural crops, urban developments, rights-of-way, recreation areas. Greater emphasis on energy production has increased disturbances from strip mining, oil and gas exploration, and development of transportation routes. Peatlands are being considered for their energy potential. Closer use of forests for fuelwood and increased emphasis on rapid fiber and fuel growth may change forest nutrient balances. Air pollution, particularly acid rainfall, has decided forest impacts both positive and negative. As urban and industrial waste problems increase, forest lands are being targeted as potential treatment sites.

The region's agricultural areas provide our country its major supplies of wheat, corn, and soybeans. Other farm products are also produced in significant quantities. Trees are important even where agriculture is the dominant land use, and shelterbelts and windbreaks are used to help conserve soil moisture, reduce wind erosion, provide wildlife habitat, and add to landscape diversity and beauty.



Parasitic wasps (upper right) introduced from Europe have brought the larch casebearer (lower right) under control in the Lake States; blue colored trees show extensive damage by casebearer.

Scope of Research

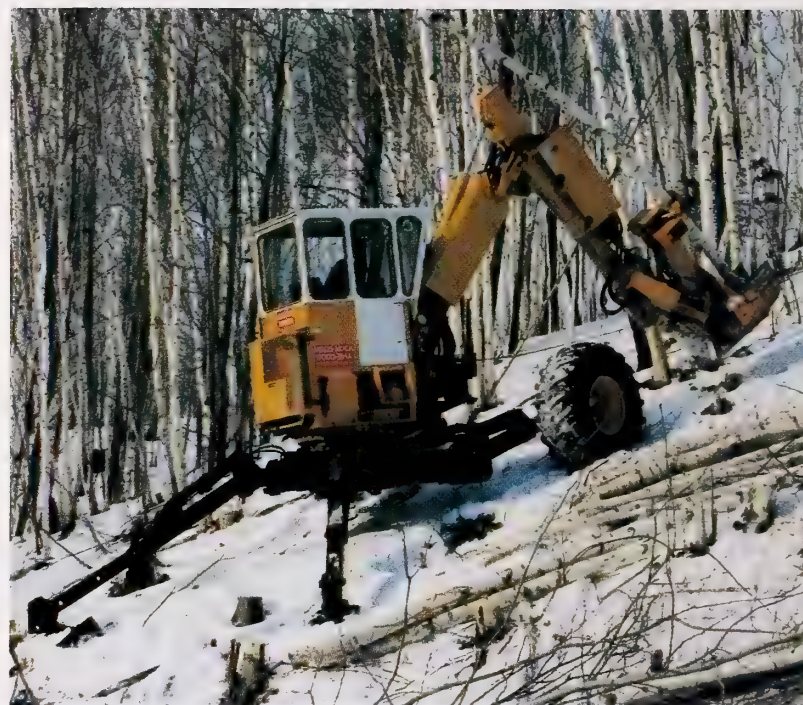
The university/Forest Service cooperative research effort in the region provides the scientific information needed to accommodate the competing demands placed on its forest resources.

As population increases and forested acreage declines, public and private forest managers and landowners must know what goods and services each acre of their land can best produce. Scientific information is needed to help them face the complex challenges of multiple-use forestry. Multiresource inventory, appraisal, and evaluation research strive to satisfy the concerns of the future: benefits and costs of different land uses, various multiple-use potentials, and efficient and accurate multiresource assessments.

Trees will grow without the help of people, but forests must be managed to produce the amount and kinds of goods and services needed by a growing population. Increasing these supplies requires new equipment and practices to improve the regeneration, growth, yield, and composition of the forest. Geneticists are developing improved trees, and economists are evaluating the expected costs and benefits from these improvements and other forest management alternatives. In addition, the research includes genetic improvement and culture of trees for special purposes such as shelterbelt plantings, watershed protection, and improvement of the urban environment.

To protect both rural and urban trees, researchers are looking for ways to prevent or minimize damage or loss caused by diseases, insects, and wildfire. Various integrated pest management techniques (including selective pesticides, biological controls, and vegetative manipulations) are being developed to minimize the mortality and growth losses caused by forest insects and diseases. Fire scientists are developing more effective prevention methods, fire danger rating systems, detection techniques, and suppression methods. Researchers are also refining prescribed burning techniques to help ensure that fire can be used as an effective, but controllable, management tool.

One way to stretch the region's wood supply is to learn how to use it more efficiently and completely. Ongoing research emphasizes the processing systems, particularly for small and presently unused wood material. Studies on the economics of wood processing and marketing are also providing useful information for landowners, loggers, and industries. Basic research on wood properties and manufacturing techniques is also underway.



This unique Swiss machine, used primarily in the construction industry, has potential for felling and bunching small timber on steep slopes.



Wildlife biologists capture small mammals as part of research on consequences of timber harvest operations.



Tree in center foreground is patented black walnut cultivar "Purdue No. 1" produced through genetics research. It is 12 years old, 44 feet high, and 8 inches in diameter 4-1/2 feet above ground. (Photo courtesy of Purdue University.)



Outdoor recreation research provides information for allocating and managing natural resources without destroying the environment recreationists seek.



Various forest uses affect the soil, water, and air. Research is concerned with alleviating pollution from forestry practices and reclaiming of mined forest and rangeland. More information is also being obtained on the effects of intensive silviculture and harvesting on water quality and nutrient cycling within ecosystems having different soil, vegetation, and geologic features. Some research scientists are also determining environmentally safe dosages of recycled waste water and sludge to fertilize the forest, while protecting the ground water.

Maintaining homes for threatened or endangered animals or plants is an important part of the North Central Region's wildlife habitat research. More information is needed on how changing vegetation affects habitats and how to predict community changes. Range research includes management of woody and forb plants, rangeland uses of nitrogen-fixing plant materials, and biological management of pests and undesirable plants.



More and more people seek the forests and waters of the region for camping, hiking, swimming, and boating. Research is assessing present and future demand for recreation sites as well as the capacity of forest lands to support them in harmony with other uses.

Environmental research is directed to the establishment, protection, and management of trees in urban areas; the rehabilitation and management of shelterbelts and windbreaks in prairie areas; the rehabilitation of disturbed lands; the use of forests for municipal and industrial waste disposal; and the protection of water quality.

Areas of Emphasis

- Increase forest productivity through improved regeneration, growth, yield, and composition.—Because land area is finite while demand for wood and other products increases, the North Central Region faces a dilemma: future supplies of wood must be produced on no more forest land than is available now—probably less.

The 78 million acres of commercial forest in the North Central States supply about 1 billion cubic feet of wood annually, but millions of acres are under-

Researchers are studying how to improve forest productivity by converting low-quality aspen-birch stands to high-quality red pine stands.

stocked or occupied by poorly formed or slow-growing trees.

For example, in the Lake States there are millions of acres of marginal farmland that would be more productive as forest. In the Central States, there are about 6 million acres of scrub brush that could be converted to productive forest.

Research is seeking ways to produce more and better wood. In addition to genetic and physiological tree improvements, we are developing better practices and equipment to prepare seedbeds and planting sites, control weeds, establish tree seedlings, and encourage the growth and development of more productive forest stands.

Research is also seeking more economic and effective ways to convert or establish desirable forests on low-productivity lands and to measure and quantify forestry benefits more precisely in economic and other terms.



- Develop more efficient ways to remove, process, and market harvested trees.—We can extend our wood supplies by learning how to make better use of them—particularly the vast resource of low-value standing timber and the logging residues from high-value species in the North Central Region.

Nearly all the wood recovered from residues, thinning, short-rotation culture, and unproductive stands could be used by the region's pulp and fiber industries. Industries using wood as a raw material—collectively, our fourth largest industrial energy consumer—have the potential to approach energy self-sufficiency by using their own residues and raw materials.

Improvements are being sought in all phases of wood utilization—harvesting, processing, marketing, development of new products, and economic feasibility.

Solar dehumidification is a promising process to reduce drying time of lumber.

Research to reduce energy consumption or to provide alternative sources of energy emphasizes studies of nitrogen-fixing plants as nurse crops and interplantings with commercial forest species, studies to minimize energy consumption in harvesting operations through more efficient equipment and harvest planning, studies to minimize consumption of energy during drying through use of heat exchangers and solar collectors, and development of wood machining equipment and operations that are more energy-efficient.

- Improve management of insects, diseases, and wildfires.—The traditional enemies of the forest—insects, disease, and wildfire—kill about 200 million cubic feet of timber in the North Central States each year—an amount equal to about one-fifth of the annual harvest. By damaging reproduction capability and impairing tree vitality, insects and diseases cause growth loss equal to another fifth of the annual harvest. Insects, diseases, and wildfires can also impair esthetic values, recreational opportunities, watershed quality, and wildlife habitat.



Research is needed on the integrated use of cultural practices, genetic resistance, and chemical and biological control of forest insects and diseases.

Traditional methods of insect and disease control have focused on one approach at a time, but frequently, one technique alone is not satisfactory. Much more research emphasis is needed on the integrated use of the most effective combinations of cultural practices, genetic resistance, and chemical and biological control to protect a variety of resources and ecosystems including short-rotation intensive culture plantations, pine plantations, various natural ecosystems, and urban forests. Three specific insect and disease research priorities are

1. the forest tent caterpillar and the spruce budworm, which defoliate aspen-birch-conifer forests;
2. insects and diseases that strike plantations, particularly those of walnut, larch, and spruce; and
3. the European strain of *Scleroderris* canker, potentially the most dangerous conifer disease in North America.

Fire research emphasizes the development and application of weather and fire danger information, characterization of the multiple effects of wildfires, and quantification of the relationships between the incidence of wildfires caused by people and fire prevention programs.

- Improve forest and rangeland inventory techniques and evaluate alternative forest investment strategies.—Inadequate financial investments in the North Central States have delayed the development of balanced, fully productive forests and range. Researchers have suggested management and protection practices that can increase productivity, but forest managers need to know the economic consequences of these developments as well as the current and projected supply of and demand for the region's forest and rangeland resources.

What are the costs and benefits of different investments? How large a tract should be planted, and where? When should it be thinned or harvested? How long will it take to make money on an investment? Answers to such questions will help forest landowners and public forest administrators make better management decisions.

Improved forest inventory techniques and evaluation systems for multiresource assessments are providing better information for resource planning and more efficient ways to manage forest resources.



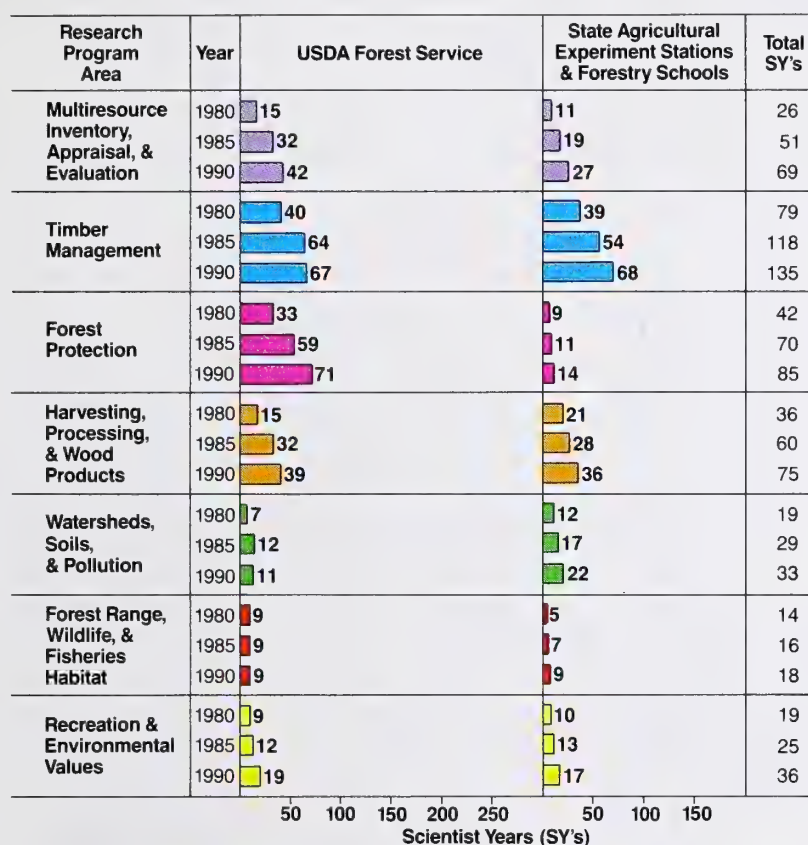
Research is underway to prevent fertile topsoil from unprotected land being blown into roadside ditches. (Photo courtesy of the University of Minnesota.)

- Use trees and forest land to improve the quality of life.—The trees and forests of the North Central Region are significantly affected by the expansion of urban, industrial, and agricultural areas. Trees and forests can help minimize some undesirable effects of such expansion by reducing soil erosion, providing sound and visual barriers, increasing wildlife habitat, and improving water quality.

Promising uses of forests for alleviating the impacts of urban, industrial, and agricultural growth are being tested. Reforestation methods for strip-mine reclamation and management techniques for protection and

North Central Region

Scientist Years (SY's) For Forestry and Associated Rangelands Research
For State Agricultural Experiment Stations and Forestry Schools,
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management of shelterbelts and windbreaks are being developed. Beneficial use of sewage sludges and effluents has been demonstrated on mined lands for some parts of the region. Upgrading low-productivity sites with sewage has been accomplished in small-scale tests. However, the long-term environmental consequences of waste applications to forest lands are unknown.

Acid precipitation is known to degrade certain lakes and to upset some aquatic populations. The impact of lowered air quality and acid rainfall on forest land productivity, ground water, and the health of terrestrial plants is largely unknown.

Research will continue to develop management techniques to improve the noncommodity benefits of nongame wildlife, outdoor recreation, and urban forestry without adversely affecting other commodity and environmental values. Research will also be continued to improve the management and use of forests and rangelands in the region by identifying the ecological impacts of urban, industrial, and agricultural growth, and determining how forests and rangelands can be used to ameliorate the impacts of that growth.

Institutions in the North Central Region Forest Resources Planning Group

Universities

Southern Illinois University
Carbondale, Illinois 62901

University of Minnesota
St. Paul, Minnesota 55108

University of Illinois
Urbana, Illinois 61801

University of Missouri
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Purdue University
West Lafayette, Indiana
47907

University of Nebraska
Lincoln, Nebraska
68503

Iowa State University
Ames, Iowa 50011

North Dakota State University
Fargo, North Dakota 58102

Kansas State University
Manhattan, Kansas 66502

Ohio State University
Columbus, Ohio 43210

Michigan State University
East Lansing, Michigan
48824

South Dakota State University
Brookings, South Dakota
57006

Michigan Technological University
Houghton, Michigan 49931

University of Wisconsin-Madison
Madison, Wisconsin 53706

University of Michigan
Ann Arbor, Michigan 48109

USDA Forest Service

North Central Forest
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Northeastern Forest
Experiment Station
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Broomall, Pennsylvania 19008

Rocky Mountain Forest and
Range Experiment Station
240 West Prospect Street
Fort Collins, Colorado 80521

The Southern Region

The Area

The Southern Region is made up of the 13 States stretching from Kentucky and Virginia south along the South Atlantic and gulf coast and west to Texas and Oklahoma. Puerto Rico and the Virgin Islands are included. The area covers 532 million acres of land. Forests and range lands are a dominant part of the landscape. Forests cover 41 percent of the area (219 million acres), and range covers 20 percent (104 million acres). A large portion—97 percent—of the range land is in Texas and Oklahoma.

Much of the South is characterized by a subtropical climate with mild winters and high humidity. The climate, soils, and topography combine to form ideal growing conditions for trees and range plants. The South's forest lands have the highest average potential for timber production of any section of the country. The forest ecosystems of the South include areas that vary from highly productive timberlands to extremely poor sites that are submarginal for investment in timber growing. Native forage grows abundantly beneath timber stands, in natural openings and on cutover lands, providing food for substantial numbers of range livestock.

The South is a major timber-producing region. Loblolly pine is the keystone of the southern pine forest products industry, as nearly half the total southern pine inventory is loblolly. Shortleaf, slash, and longleaf are other important southern pine species. Oak-pine, oak-hickory, swamp and bottom-land forests have long been the mainstay of the southern hardwood forest products industry. Other forest ecosystems that occur in the South account for less than 19 percent of the total forest area. Most of this acreage consists of woodlands that are largely useful for nontimber goods and services such as grazing, wildlife, and recreation.

Most forests of the South provide good to excellent habitat for wildlife. The hardwood and mixed hardwood-conifer forests generally provide better habitat for a wide variety of wildlife than do the pine forests.

Recreational opportunities abound in the South's forests, which are focal points for many forms of outdoor recreation such as hunting and fishing.

Research has shown how prescribed burning can be used to eliminate insect-and disease-prone trees from forest stands.







Over 90 percent of the forest and range lands in the South are under private ownership. About four-fifths of the private forest lands are in nonindustrial ownership. During the past quarter century, forest area in the South has changed as the result of shifts in land use. In 1952, forest land totaled over 225 million acres; a decade later it had increased to almost 231 million acres, and since has declined to a level of 219 million acres. This decline signaled the end of significant additions to forest through abandonment of crop and pasture land. Losses of forest lands to other uses will continue as the Sunbelt population increases.

The South's forests are expected to produce half the Nation's wood product needs by the year 2000, while providing ample quantities of livestock forage, clean water, wildlife habitat, and recreational opportunities.

The average acre of forest land in the South is capable of growing two to three times more timber than at present. Production of red meat on forest and range lands could be increased greatly, and populations of many wildlife species and opportunities for recreation in the South could be increased with proper management of existing forest resources. This potential offers a unique challenge to forestry research, because most of the gain in forest goods and services must come from small, nonindustrial ownership.



Top
Low-altitude color infrared imagery is used by research to measure ecological impacts of water impoundments (blue color) on forest environments. (Photo courtesy of Mississippi State University.)

Above
Studies of wild turkey habitat provide information for game management. (Photo courtesy of Mississippi State University.)



A technician removes circular bark samples to study bark beetle populations. (Photo courtesy of Texas A. & M. University.)

Scope of Research

The key to meeting the South's goals for goods and services from forests and rangelands lies in more intensive management and better utilization practices. Developing ways to achieve these two objectives and the need to foresee and provide acceptable solutions to attendant problems are the challenge to forestry research.

Multiresource inventory, appraisal, and evaluation are vital to meeting future demands for forest goods and services. A constant check on supply of available resources is required along with predictions of future demands and changes in ownership pattern. And, because the forest land base is decreasing, we must develop ways to accommodate multiple uses in conjunction with increased timber production.

Timber production per acre must be increased if the South is to satisfy future demands for forest goods and services. This translates into the culture of about 70 pine and hardwood species from forest establishment through harvest to reestablishment. While considerable research attention must be given to pine forests, we cannot meet overall land management and production goals without advancements in hardwood silviculture. Genetic improvement and economics are important elements of such hardwood timber management research.

Insects and diseases will become more important as intensive management increases. While the southern pine beetle is the major pest in the region, it is by no means the only enemy. Other insects, diseases, and wildlife claim a sizable portion of the potential timber volume each year. Wildfire will become more costly as forest investments rise and plantations of genetically improved trees are established.

The South is in the midst of a veritable industrial revolution, in the woods and mills, brought on by rising costs, increased demands for wood products, and scarcity of labor. Changes in harvesting, processing, and marketing of forest products must continue, or the lack of suitable processes and equipment could be a major limiting factor in forestry advancement.

Any use of forest lands has environmental impact—good and bad. As forest management intensifies in the South, protection and enhancement of site productivity and air and water quality become even more important considerations.



*Aerial view of southern pine beetle infestation.
This bark beetle kills thousands of acres of pine
annually in the South.*



A "friendly forest monster," developed by research engineers, chews its way through scrap trees and forest residue, gobbling up 25 tons per acre to make forests more productive.

Outputs from southern forests include far more than timber. The forage production potential is greater on southern forests than on any other region. Research is needed on development of ways to produce timber, forage, and a wide variety of wildlife and fisheries habitats through integrated management practices.

Forests and rangelands provide a wide variety of nonconsumptive and cultural values to the American public, values that are steadily assuming greater significance. Researchers on forest recreation and environmental values have the goal of identifying these values and increasing their availability to user groups.

Areas of Emphasis

- Develop new techniques for integrated pest management.—While useful pest management research in the traditional sense has been underway for many years, basic and applied research to support a fully integrated pest management program for a particular pest or complex of pests in specific forest ecosystems is needed. Significant gaps exist in our basic understanding of pest/host/environmental interactions, and in ways to deal with these situations under a broad array of environmental and managerial conditions. Initially, major research emphasis must focus on individual insects and disease in relatively limited plantations or forest ecosystems. Subsequently,

information on pest/host impact and benefit/costs of alternative treatment tactics and strategies must be linked and tested, first in limited areas, then over broader regions.

- Develop new techniques for vegetation management.—A major challenge to southern forestry is the control of noncrop vegetation by cost-effective and environmentally acceptable methods such as grazing by domestic livestock. A coordinated Southwide research effort is needed to ascertain cost-effective vegetation control systems for specific sites and problem areas (e.g., improvement of water quality and yield). Research on mechanical site preparation treatments, development of selective herbicides for pine release, and assessment of the use of fire as a cultural treatment should be included.

- Develop management practices that will improve the regeneration of southern forests.—The present rates at which southern forests, particularly pines, are being regenerated will not meet anticipated demands in the 21st century. Inventory analyses need to be improved to describe more accurately the magnitude of the regeneration problem on a continuing basis. Basic research directed toward understanding biological changes associated with site preparation needs to be increased. We need harvesting procedures that will permit natural regeneration to be protected. We also need natural regeneration practices applicable to small forest ownerships. High-quality seeds and seedlings need to be developed along with improved nursery practices.

- Develop new techniques for improving forest land productivity.—The effects of long-term physical changes in most forest soils from intensive forest management are not known and may be of major consequence to the productivity of certain soils. Expanded research is needed on the effects of full tree utilization on soil properties, tree growth rates, and physiology in succeeding rotations. Information is needed on the effects of different site preparation practices on soil physical properties, nutrient reserve, biota, and long-term productivity. The use of heavy woods equipment on soils, and the best methods of maintaining productivity by minimizing damage and accelerating the rehabilitation of damaging compaction and puddling are important research problems. We also need economic analyses of the investment opportunities for wood and forage production.

Southern Region

Scientist Years (SY's) For Forestry and Associated Rangelands Research
For State Agricultural Experiment Stations and Forestry Schools,
and USDA Forest Service For 1980, 1985 and 1990

Research Program Area	Year	USDA Forest Service	State Agricultural Experiment Stations & Forestry Schools	Total SY's
Multiresource Inventory, Appraisal, & Evaluation	1980	23	15	38
	1985	55	25	80
	1990	70	35	105
Timber Management	1980	86	70	156
	1985	124	98	222
	1990	150	125	275
Forest Protection	1980	70	16	86
	1985	94	20	114
	1990	125	25	150
Harvesting, Processing, & Wood Products	1980	27	42	69
	1985	51	64	115
	1990	63	85	148
Watersheds, Soils, & Pollution	1980	20	15	35
	1985	34	22	56
	1990	40	28	68
Forest Range, Wildlife, & Fisheries Habitat	1980	13	24	37
	1985	37	32	69
	1990	48	40	88
Recreation & Environmental Values	1980	4	6	10
	1985	10	7	17
	1990	15	9	24

50 100 150 200 250 50 100 150
Scientist Years (SY's)

- Improve use of wood for energy.—The expanded interest in the use of wood fuel has indicated many gaps in our knowledge of the production, harvesting, and conversion of wood for energy. We need to develop more efficient ways of preparing and converting wood fuels to energy.
- Develop methods to protect, select, establish, and value urban forests.—Urban forests represent a major public investment; millions of dollars are spent annually to maintain this investment. Yet little research-based technology is available on which to base urban forest management decisions. Research is also needed on the scope and magnitude of the benefits from urban forests.

Institutions in the Southern Region Forest Resources Planning Group

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71655

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University of Georgia
Athens, Georgia 30602

University of Kentucky
Lexington, Kentucky
40506

Louisiana State University
Baton Rouge, Louisiana
70893

Louisiana Tech University
Ruston, Louisiana 71207

Virginia Polytechnic
Institute
and State University
Blacksburg, Virginia 24061

Mississippi State University
Mississippi State,
Mississippi 39762

North Carolina State
University
Raleigh, North Carolina
27650

Oklahoma State University
Stillwater, Oklahoma
74074

Clemson University
Clemson, South Carolina
29631

University of Tennessee
Knoxville, Tennessee
37901

Texas A. & M. University
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77843

Stephen F. Austin State
University
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The Northeastern Region

The Area

The Northeastern Region covers 12 States and is an area of many contrasts. Twenty-seven percent of our population lives here on only 6 percent of the country's total land area. About 80 percent of the 56 million residents live and work in a metropolitan environment. The region's highly concentrated population is characterized by the sprawling megalopolis extending from Boston to Washington, D.C. Yet the Northeastern Region is heavily forested despite its vast urbanization. The percentage of total land area that is tree covered—58.5—is higher than for any other region.

As in the South, the majority of forest land is in small, private tracts. Of the 87 million acres of forests in the Northeast, more than 73 percent is in nonindustrial private ownership held by an estimate 2 million owners. Only 10.5 percent of the region's forest land is publicly owned, compared with 28 percent for the Nation as a whole.

Hardwoods occupy the majority of northeastern forest land and provide a resource base for many forest-related industries. Timber-based industries contribute \$8 billion annually to the region's economy. One-fourth of the our pulpmills are located here; they carry one-tenth of the national wood pulping capability. About 2.3 billion board feet of sawlogs are cut each year in the Northeastern Region.

Another characteristic of this region is that the value of nontimber goods and services may be as high or higher than that of traditional timber products.

At least 30 percent of the population in this region depends on surface water for drinking. This water comes from forested municipal watersheds and forest-bounded reservoirs. Because virtually all of the forest land in the Northeastern Region is within easy reach of the resource user, thousands of residents turn to these forests for unique recreational opportunities not found in cities. The region's forests also provide habitats for a wide assortment of wildlife and fish.

During the next half century, the demand for goods and services from the region's forest resource is expected to continue increasing. In addition, industrial, residential, and other uses are expected to consume an ever greater amount of the forested acreage.



Researcher collects yellow birch seed for hardwood research studies. (Photo courtesy of the University of Vermont.)



Leaves of honey locust tree are collected to determine the water needs of urban trees. (Photo courtesy of the University of Connecticut.)

Multiple-use of forest lands must be done by meeting landowners' objectives while maintaining the quality of the environment.



Society's deepening dependence on renewable natural resources has created the potential for disagreement over the use of the forest resource. Although differences of opinion on the use of forest lands are not unique to the Northeastern Region, these differences assume a greater intensity here because of the combined concentration of people and forests.

Differences in political atmosphere, climate, and topography also have produced different problems within the region. These differences, coupled with heavy pressures on forest use, make it an ideal area for research on conflicts in forest use. Much of what is learned here can serve as a model for other regions where population pressures have not yet reached the advanced stage found in the Northeast.

Scope of Research

The increasing demand for wood products, coupled with decreasing availability from southern and western forests, will place unprecedented pressures on the eastern hardwood resource during the next 50 years. Of particular concern are recent increases in the use of the region's hardwoods for fuel. The extent to which such use will have a positive or negative impact on the future resource base is the source of much speculation; acquiring this knowledge is essential for the wise use of the region's hardwood resource and associated softwood species, especially spruce, fir, and white pine.

The Northeastern Region's large, concentrated population underscores the need for effective management of the hardwood forests to meet increasing demands for goods and services from this valuable resource. Resource management plans must consider the myriad objectives of the large numbers of nonindustrial owners of small forest tracts.

There is great potential for forest lands to expand the region's economic base, particularly in rural areas, where the income of many residents is at or near the poverty level. Research is needed to develop additional uses for forest products, and to determine ways to generate income from other forest-derived goods and services. Making the most effective use of both commodity and noncommodity forest production through a greater knowledge of multiple-use of forest lands must be done by meeting landowner objectives while maintaining the quality of the environment. Policies on forest resource use also must be based on an understanding of the needs of both the rural landowner and the urban dweller.

Timber management research requires (1) tending many species from seed production through harvest and stand regeneration, (2) developing genetically superior stock, and (3) evaluating the costs and returns from genetic improvement and various silvicultural practices.

Reducing economic losses from insects and diseases can dramatically increase the quantity and quality of the products and benefits available from the Northeastern Region's forest resource. Despite the influence of natural regulatory organisms, the gypsy moth remains the dominant pest of eastern hardwoods. In addition to the complex of pest problems associated with hardwood forests, white pine and spruce-fir suffer severe losses to the white pine weevil and the spruce budworm.

In Maine, studies have shown that 4 million of the State's 7 million acres of spruce-fir forests must be protected against spruce budworm losses to produce enough wood to meet requirements of existing industry. The yield of all forest products from the Northeast will be modified by periodic outbreaks of the spruce budworm. Problems associated with this insect are increased by growing opposition to the use of chemical pesticides to control budworm populations. Integrated pest management has the greatest potential for reducing the use of chemical control agents.

Revegetation of surface-mine spoils in the Northeastern Region is critical for controlling erosion, enhancing esthetic values, and restoring mined land to productive use. Planting compatible combinations of species is designed to produce a quickly established and permanent or long-lived cover. Revegetation of steep slopes and toxic spoils requires the application of soil amendments, the planting of acid-tolerant species, and the introduction of beneficial microorganisms.

Demands for eastern coal as an energy substitute for gas and oil, and the extraction of other minerals are expected to continue. Surface mining can pose a serious threat to the environment. The Northeastern Region receives large quantities of air pollutants from industries in the East and Midwest. In many locations throughout the region, precipitation is becoming increasingly acidic, which results in additional stress on aquatic and forest ecosystems. Forest management is further complicated by the increasing use of forest lands for the disposal of municipal wastes.

The most desirable opportunity for increasing wildlife populations is through more intensive habitat management in places close to urban centers, where large numbers of people might benefit. The Northeastern Region is a prime area for this research because the opportunities are great, and because the region can serve as a model for national programs on urban forestry and related programs. Research is needed to find ways to improve ecosystems on which endangered and threatened species of wildlife depend.

The presence of a great many people in the land areas of the Northeastern Region places great pressure on the managers of public and private lands to provide outdoor recreation opportunities and to maintain or improve amenity values. This pressure will continue to increase as the amount of leisure time available to individuals increases. Research must provide means for enhancing recreational experiences while protecting the unique character of the region's recreation resource.

Areas of Emphasis

- Provide better measures of the amount, quality, and availability of the eastern hardwood resource so that long-term planning can be carried out to meet projected demands, including those for energy production.—Opportunities for extending the hardwood resource will be explored. At present, more than 50 percent of the total fiber in each tree is left in the woods.

- Develop new utilization, harvesting, and marketing technology for the effective use of the current surplus of low-quality and small-size hardwoods.—Harvesting research will find ways to remove more of this fiber from the forest economically. Converting this timber into furnishings, housing components, and other products will allow the substitution of hardwoods to offset the diminishing supply of softwoods. Benefits will accrue in the form of new industries, more jobs for people in the region's rural areas, and higher incomes from woodlands for the owners of forest land.

- Explore new markets for presently unmerchantable timber and residues to increase supplies of wood fiber for energy production.—The use of hardwoods for fuelwood and woody biomass for energy applications can have a major impact on the region's forest resource and its management. Guidelines will be developed on how best to meet these energy demands while simultaneously using, protecting, and managing

the forest resource for all its other commodity and noncommodity values. Studies on the economics of wood processing will provide useful information for forest landowners, loggers, and wood-using firms.

- Enhance the management, use, and productivity of the Northeastern Region's forest lands.—The productivity and quality of the forest resource needs to be improved through development of silvicultural and forest management practices appropriate for the ownership patterns of the region. We also need more information about the consequences of alternative uses of land and resources. Also, research needs to determine ways to improve the quantity of wildlife habitat.

- Develop methods to weigh the costs and benefits of different land uses, to evaluate more accurately the multiple-use potential of land, and to assess the quantity and value of the products available from this resource.—Guidelines will be developed for evaluating the suitability of land for specific uses and for classifying forest land to minimize degradation from undesirable uses. Methods of forest taxation prevalent in the Northeastern Region will be examined.

- Develop and refine efficient yet environmentally acceptable substitutes for—and complements to—chemical pesticides in combating forest insect pests.—A substantial research effort will be directed toward developing and coordinating the use of alternative control measures in a unified system of integrated pest management.

- Consolidate all available necessary control techniques so that insect populations can be managed in ways that avoid or reduce economic damage and minimize adverse environmental effects.—Management options will range from doing nothing in certain situations to using cultural practices and harvesting, biological control agents, behavioral chemicals and pesticides, and combinations of these measures.

- Organize parallel program of research that concentrates on reducing disease and decay in trees through silvicultural, biological, genetic, and chemical



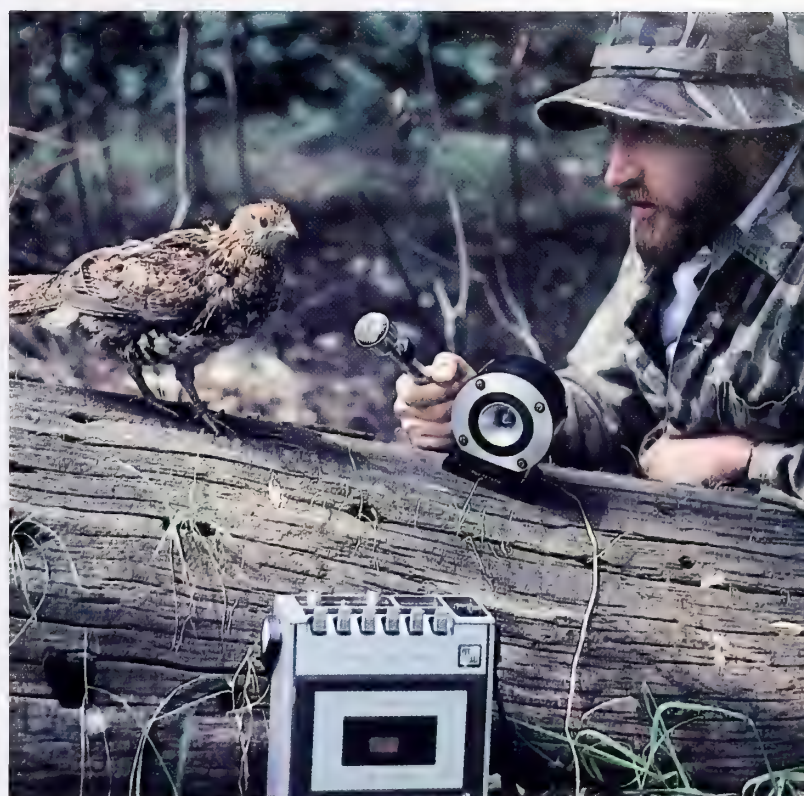
Samples of soil solutions, extracted with suction lysimeters, provide information about changes in acid rain as it passes through the soil.

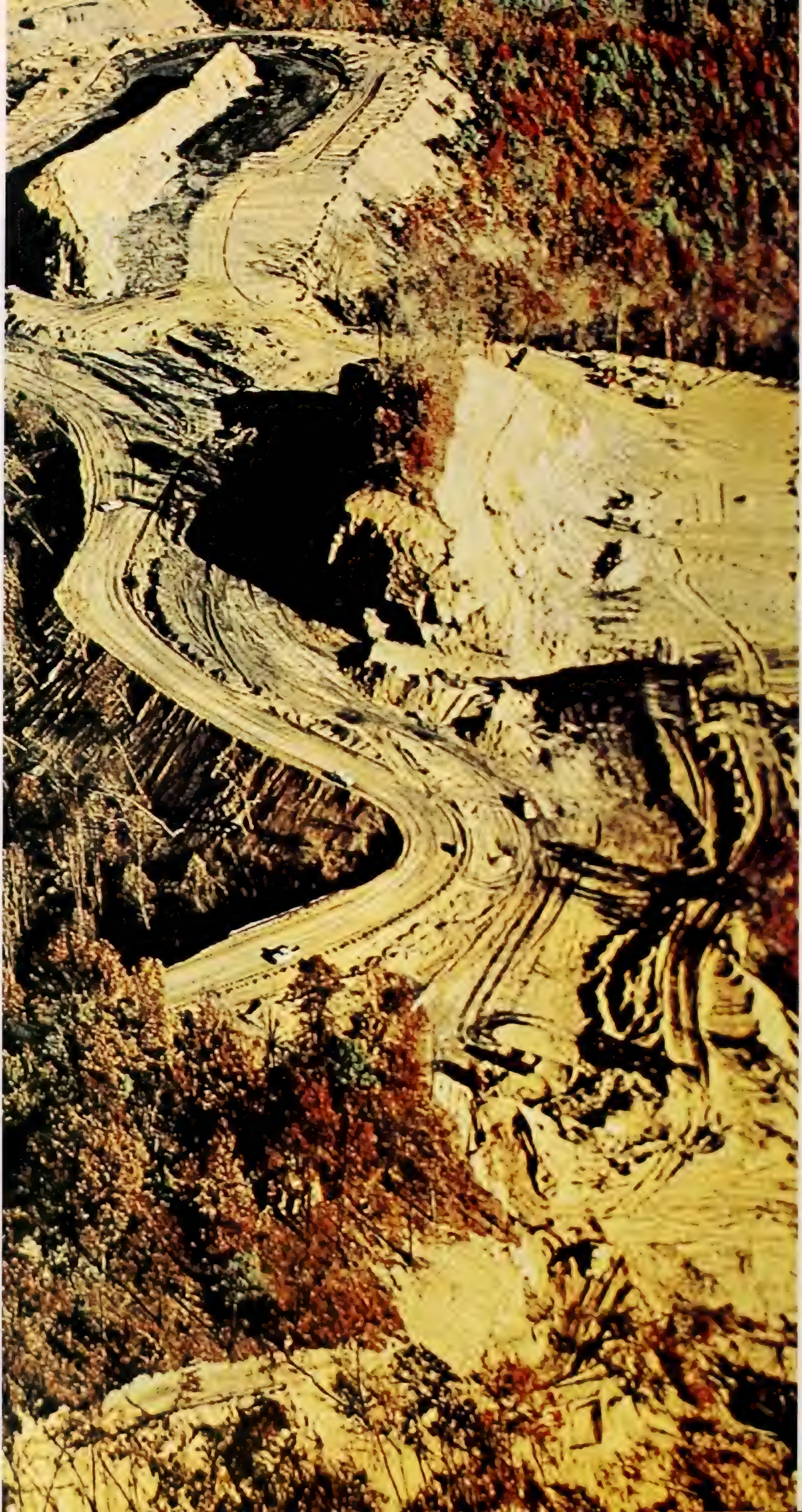
Researcher records the call of a ruffed grouse. The tape helps biologists to find grouse broods, manage populations, and assess habitat quality.

Increasing the productivity of the eastern hardwood resource provides many challenges to research.

methods, including the selection of resistant tree varieties.—As forest management becomes more intensive, a greater research effort will focus on controlling insects and disease in young stands, plantations, and nurseries. All research on insects and disease will emphasize prevention as well as control and will address problems not only in rural forests but also in urban and urban-rural fringe areas.

- Provide efficient and cost-effective measures to reclaim mine lands, to satisfy legislative standards and requirements.—Research will consider ways to minimize adverse environmental effects of mining, both at the site where the coal is extracted and downstream. We will develop methods for controlling nutrient and sediment losses associated with forest management and timber removals, and for maintaining the quantity and quality of municipal water supplies and safeguarding soil productivity.





Research is needed on rehabilitation techniques that will minimize the adverse impacts of mining.

Northeastern Region

Scientist Years (SY's) For Forestry and Associated Rangelands Research
For State Agricultural Experiment Stations and Forestry Schools,
and USDA Forest Service For 1980, 1985 and 1990

Research Program Area	Year	USDA Forest Service	State Agricultural Experiment Stations & Forestry Schools	Total SY's
Multiresource Inventory, Appraisal, & Evaluation	1980	16	23	39
	1985	21	33	54
	1990	25	42	67
Timber Management	1980	32	26	58
	1985	40	36	76
	1990	43	47	90
Forest Protection	1980	20	24	44
	1985	24	34	58
	1990	24	44	168
Harvesting, Processing, & Wood Products	1980	33	28	61
	1985	39	40	79
	1990	49	51	100
Watersheds, Soils, & Pollution	1980	10	21	31
	1985	13	29	42
	1990	16	38	54
Forest Range, Wildlife, & Fisheries Habitat	1980	3	30	33
	1985	11	42	53
	1990	13	54	67
Recreation & Environmental Values	1980	5	26	31
	1985	9	36	45
	1990	9	46	55

- Assess the effects of acid precipitation and other forms of atmospheric deposition on forest streams, lakes, soils, and plant life, as well as the effects of forests in ameliorating pollution.—The impacts of these pollutants on urban areas also will be evaluated. Researchers will seek methods that allow the safe disposal of sewage wastes on forest lands, and work toward establishing permissible application levels.

- Provide data that enable resource managers to choose alternative methods of increasing the availability of outdoor recreation experiences to segments of society.—Information on user benefits from dispersed recreation—and on the cost of providing these benefits—will aid managers in making decisions on land use. It is doubtful that the relatively small acreage of public lands in the Northeastern Region will be able to accommodate the anticipated stresses on the recreation resource. Particular attention must be given to examining the role of private forest lands in producing public recreational opportunities. Research is also needed to evaluate the role that urban forests can play in reducing recreational impacts on rural forest productivity.

Institutions in the Northeastern Region Forest Resources Planning Group

Universities

University of Connecticut Connecticut Agricultural Experiment Station New Haven, Connecticut 06504	University of New Hampshire Durham, New Hampshire 03824
University of Connecticut Storrs, Connecticut 06268	Pennsylvania State University University Park, Pennsylvania 16802
Cornell University Ithaca, New York 14853	University of Rhode Island Kingston, Rhode Island 02881
University of Delaware Newark, Delaware 19711	Rutgers, The State University of New Jersey New Brunswick, New Jersey 08903
University of Maine Orono, Maine 04473	State University of New York College of Environmental Science and Forestry Syracuse, New York 13210
University of Maryland College Park, Maryland 20742	University of Vermont Burlington, Vermont 05401
University of Massachusetts Amherst, Massachusetts 01002	West Virginia University Morgantown, West Virginia 26506

USDA Forest Service

Northeastern Forest Experiment Station
370 Reed Road
Broomall, Pennsylvania 19008

Forest Products Laboratory

Location

The Forest Products Laboratory is maintained in Madison, Wisconsin, in cooperation with the University of Wisconsin. Established in 1910 as the national center for wood utilization research, it has achieved worldwide recognition for its accomplishments in expanding our knowledge of wood and wood-based products.

Scope of Research

The mission of the Forest Products Laboratory is to conduct research leading to greater social and economic benefits for the people of the United States—and of the world—through better use of the timber resource. Currently, the laboratory has established a threefold approach to this mission: (1) to insure the most efficient use of wood as an industrial material, (2) to assist timber resource management, and (3) to provide worldwide expertise on the technical aspects of wood.

As a renewable resource, America's forests play a major role in providing a continuous supply of raw materials to help meet the needs of a growing population. These forests will return maximum values to the people of the United States only if they are fully and profitably used, and at the same time maintained in a flourishing condition for the continuous production of timber crops.

By exploiting wood's versatility, we can expand the range of timber products while extending the resource through more efficient processing methods. Utilization research must aid in solving many difficult problems, such as how to more efficiently use the smaller second-growth trees that will form the bulk of future forests; how to secure useful service from the many wood species that are now used little if at all; how to capture economically the large quantities of residues that occur in the conversion of trees into commodities; how to secure greater service and economy from wood through selection of material, control, and modification of its properties, improvement of treating processes, and development of new and better methods of wood fabrication and conversion.

The Forest Products Laboratory staff of approximately 340 employees includes over 200 scientists, professionals, and technicians, with the remainder administrative and support personnel. Specialists include chemists, engineers, physicists, botanists, plant pathologists, mathematicians, forest products technologists, and economists. The laboratory's facilities consist of more than 10 large buildings

located on 22 acres of land at the west end of the University of Wisconsin campus.

The laboratory shares important partnerships with the academic community and with other government agencies. About 10 percent of the research is accomplished on a cooperative basis with some 45 universities.

Areas of Emphasis

- Optimize material properties.—Presently, wood and wood-based materials are not used to maximum efficiency because we do not know enough about wood's material properties. The process of fabricating reconstituted panel and fiber products provides an opportunity to produce engineered materials that optimize particle or fiber properties to meet specific end-use requirements and reduce overdesign. In addition, anatomical and growth characteristics could be correlated with related properties to attain more efficient structural applications. This will require basic research leading to an understanding and optimization of properties of wood materials and their application to design.
- Improve production of wood-based chemicals.—The production of wood-based chemicals, such as rosin, vanillin, and fatty acids, is assuming increased importance with the escalating cost of petroleum. Petrochemical substitutes also appear to provide important opportunities for the development of new adhesives. Wood will become increasingly important as a source of these and other new chemicals. Fundamental research on the chemical breakdown of wood and related byproducts is required to achieve this potential.
- Extend timber supplies through improved processing.—An important and effective way of extending timber supplies is to improve the product yield from each unit of wood input. As a result of past improvements, timber use has shown steady gains since the late 1950's, rising at an annual rate of just under 0.8 percent per year. Further research on improved processing techniques and products is required to maintain this momentum, particularly in view of the declining size and quality of the timber.
- Improve structural applications.—Wood structures have repeatedly withstood the test of inservice performance. But with the changing resource situation, past construction practices may be inadequate to meet



future needs. Lower-grade material is now going into construction, and reconstituted products of residues and lower-quality fiber are gaining in structural applications. These changes in material use are occurring without adequate design technology to evaluate their effect on end-use performance. For efficient materials use, materials and material properties must be developed for specific end uses. This will require basic research on the interrelationships among material properties, design, and end-use performance.

- Utilize residues and recycled fiber.—Due to past utilization practices, much of the hardwood forest is composed of low-quality trees that cannot be economically harvested for processing. During harvesting, only about one-half of the material is removed, and additional residues are generated in each subsequent step in the processing chain. Finally, wood-based wastes generated in urban areas constitute a disposal problem as well as a potential source of fiber. Research is needed to develop technology for the manufacture of wood-based products, energy, and chemicals from forest and mill residues and urban wastes.
- Produce and conserve energy.—Only about 2 percent of our national energy budget is produced directly or indirectly from the forest, but this could be increased to about 8 percent with improvements in utilization technology. Possibilities include improved liquid fuels from wood and improvements in wood combustion processes, such as fluidized bed and suspension burning. Another contributing feature is the encouragement of energy conservation through less energy-intensive manufacturing techniques and improved building designs



Research has developed a truss frame construction system that reduces the use of frame material by 30 percent, thus saving lumber and reducing costs.

Use of microorganisms can reduce both the amount of energy needed to remove lignin from plant fibers and the pollution caused by this process.

Forest Products Laboratory (USDA Forest Service)

**Scientist Years (SY's) for Forestry and Associated
Rangelands Research for 1980, 1985, and 1990**

Research program area	1980	1985	1990
	Scientist Years		
Forest protection	7.8	14.5	17.6
Harvesting, processing, & wood products	97.2	226.4	269.6
Watershed, soils, pollution	0	0	7.5
Total	105.0	240.9	294.7

Present And Projected Forestry Research Effort

The combined university-USDA research effort is outlined for the base year 1980 with projections for 1985 and 1990 for both the universities and the USDA Forest Service. The research is divided among seven research program areas, each encompassing two or three research problem subject categories. For each problem area, we also describe the types of studies that would be involved and identify the regions where the studies would be given special emphasis. The seven research program areas are:

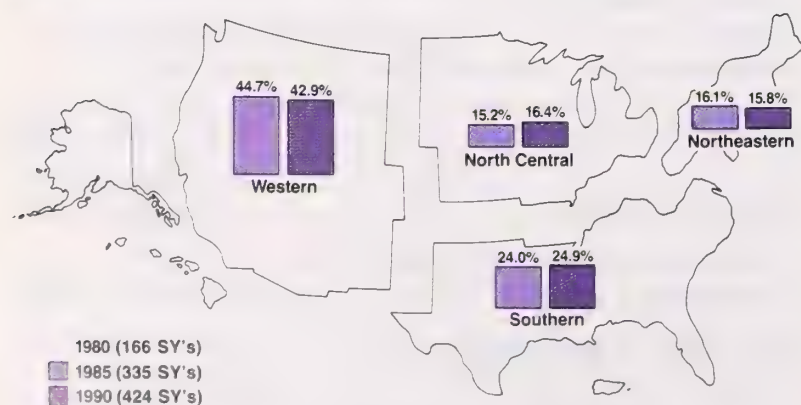
1. Multiresource inventory, appraisal, and evaluation
2. Timber management
3. Forest protection
4. Harvesting, processing, and marketing of wood products
5. Forest watersheds, soils, and pollution
6. Forest range, wildlife, and fisheries habitat development
7. Forest recreation and environmental values

All research efforts are expressed in Scientist Years (SY's). A scientist year includes all technical and clerical support, together with facility, administrative, and other operational costs necessary to support one scientist for 1 year. A scientist employed by the Federal government is defined as one who holds a grade of GS-11 or higher. A university scientist is considered to hold the equivalent rank of assistant professor or above.

Although the research program and problem areas appear to be independent, research often transcends the boundaries of a particular area. For example, much of the research effort planned for forest protection, watersheds, harvesting, and other programs (as evidenced by the descriptions of some of the proposed studies) will be helpful in enhancing forest recreation and environment values.

Percentage Distribution of Scientist Years (SY's)

Multiresource Inventory, Appraisal, and Evaluation



Present and Projected Forestry Research by Research Areas: 1980, 1985, 1990

Research program area	1980	1985	1990
Scientist Years			
Multiresource inventory, appraisal, and evaluation	166.4	335.1	423.7
Timber management	404.1	578.1	698.5
Forest protection	320.5	451.9	554.9
Harvesting, processing, and marketing of wood products	308.5	552.5	677.5
Forest watersheds, soils, and pollution	176.3	293.2	386.6
Forest range, wildlife, and fisheries habitat development	177.9	302.6	368.0
Forest recreation and environmental values	86.8	133.4	167.6
Total	1,640.5	2,646.8	3,276.8

Multiresource Inventory, Appraisal, and Evaluation

Most Americans favor multiple use of forest lands. But which uses and where? Conflicts are growing because we are demanding more goods and services from the Nation's limited forest and rangeland base, while at the same time there is an increased environmental awareness on the part of the public.

Only one natural resources pie is available. How do we slice it to achieve the maximum benefit for the general public? First, we need to know how much we

Research problem area	1980	1985	1990
Scientist Years			
Multiresource inventory, appraisal, and evaluation	99.2	204.9	257.3
Alternative uses of land	13.4	25.5	31.8
Multiple-use potential and evaluation	53.8	104.7	134.6
Total	166.4	335.1	423.7

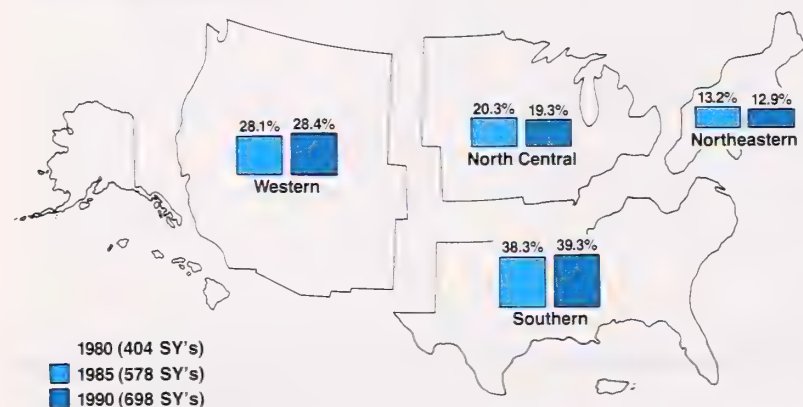
have of our limited resources and where they are located. Then we must determine what the demand is for each of these resources. We must learn how much of each product or service the land base can produce and at what cost. Finally, we must be able to evaluate the physical, social, and economic implications of land-use strategies and assess their long-term effect on the United States and world economy. Such questions are addressed by multiresource inventory, appraisal, and evaluation research.

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL ¹
Multiresource inventory and appraisal	• Conduct comprehensive State assessments to inventory and evaluate renewable forest resources.	•	•	•	•	
	• Improve techniques for inventorying and estimating future resource supplies.	•	•	•	•	
	• Improve techniques for evaluating the impacts of alternative management practices on future resource supplies.	•	•	•	•	
	• Develop remote sensing technology to improve efficiency of multipurpose inventories to detect changes in vegetative cover and to improve land management planning systems.	•	•	•	•	
	• Improve mensuration and biometric techniques.	•	•	•	•	
	• Develop economic analysis procedures for selection of alternative land management planning.	•	•	•		
	• Analyze forests for bioenergy production.	•		•		•
	• Improve methodology for remote sensing of range resources.	•				
Alternative uses of the land	• Develop a better understanding of the factors causing major land allocation changes and land use conflicts.	•	•		•	
Multiple-use potential and evaluation	• Develop economic and sociological evaluation procedures for determining multiple-use potentials.	•	•	•	•	•
	• Develop methods for watershed protection in urban areas.	•				
	• Develop information base and techniques for resolving land-use conflicts.	•	•	•	•	
	• Improve technology to inventory, recover, and maximize production and conversion of wood for energy.	•	•	•	•	•

¹W = Western Region, NE = Northeastern Region, NC = North Central Region, FPL = Forest Products Laboratory, S = Southern Region. These abbreviations also will be used for the regions where studies would be conducted for all research problem areas.

Percentage Distribution of Scientist Years (SY's)

Timber Management



Timber Management

Left to their own devices, trees will grow without the help of people. But forests must be managed to produce the different kinds and qualities of forest goods and services demanded by a growing population. Need for forest products will double by the year 2000, and timber management research must provide ways to boost timber production to satisfy this need. Concurrently, new and increased demands are being made on forest resources from an expanding human population with greater amounts of leisure time and increasing appreciation for noncommodity values. Timber management research, therefore, must not only provide new knowledge about the culture, breeding, and economics of growing trees. It must achieve this goal in harmony with other forest values.

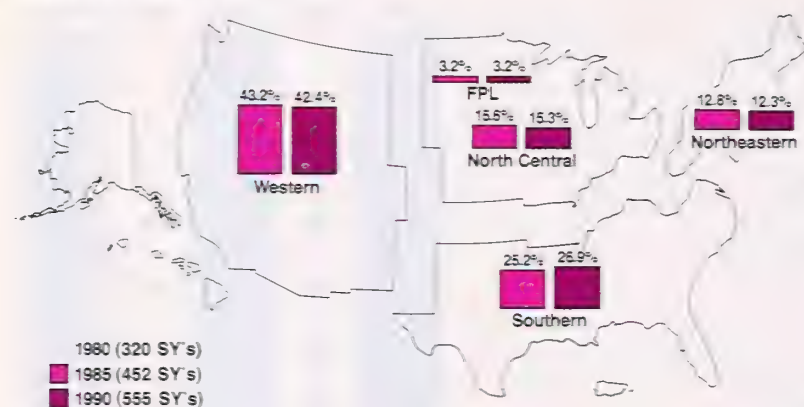
Basic timber management research involves the culture of more than a hundred tree species through the entire range of forest management practices from seed production to harvest and stand reestablishment. These aspects of understanding the resource extend beyond management for timber. Physiology, genetics, and ecology of forest trees are also valuable to the urban forester, the recreational land manager, and the wildlife manager. This research includes development of improved trees for faster growth and greater disease and insect resistance. It also includes the economic evaluation of expected costs and benefits from genetic improvement, thinning, forest fertilization, and alternative cultural methods.

Research problem area	1980	1985	1990
Scientist Years			
Biology, culture, and management of forests and timber-related crops	294.9	427.4	506.9
Genetics and breeding of forest trees	72.9	101.7	126.2
Economics of timber production	36.3	49.0	65.4
Total	404.1	578.1	698.5

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL
Biology, culture, and management of forests and timber-related crops						
	• Develop new intensive timber culture techniques.	•	•	•	•	
	• Improve techniques for forest regeneration.	•	•	•	•	
	• Improve techniques for predicting forest growth and yield.	•	•	•	•	
	• Determine the impact of alternative timber management practices on other resources.	•	•	•		
	• Develop a better understanding of conifer physiology including the role of plant hormones.	•	•		•	
	• Determine the impacts of Mt. St. Helens's eruption on forest productivity.	•				
	• Increase forest biomass production through forest fertilization.	•		•		
	• Improve techniques for management of shelterbelts and other special purpose plantings.		•			
	• Develop cost-effective noncrop vegetation control systems for specific sites and problem areas, including the controlled and selective use of fire, herbicides, and mechanical site treatment.	•		•		
Genetics and breeding of forest trees						
	• Develop breeding techniques and improved genotypes of important timber species.	•	•	•	•	
	• Determine genetic variability and its implications.	•	•	•	•	
	• Compare planting methods with subsequent survival of germinants.	•				
	• Develop high-quality seeds and seedlings and improve nursery practices.	•		•		
	• Find natural regeneration practices applicable to small forest ownerships.			•		
Economics of timber production						
	• Evaluate economic effects of changing technology trade on joint production.		•	•	•	
	• Understand public and private forest investments, opportunities, and effects of forest production.	•		•	•	
	• Develop improved economic analyses methods for timber management decisions.	•				
	• Develop improved marketing and managerial systems for both public and private forests.		•			

Percentage Distribution of Scientist Years (SY's)

Forest Protection



Forest Protection

Insects, diseases, and wildfires kill an estimated 2.4 billion cubic feet of timber annually—an amount equal to one-fifth the annual harvest. Insects and diseases also cause approximately the same amount of annual growth loss. In addition to these damages, the three factors together impair esthetic values, recreational opportunities, watersheds, and wildlife habitat. In rural and urban areas, insects and disease may cause a significant reduction in real estate values.

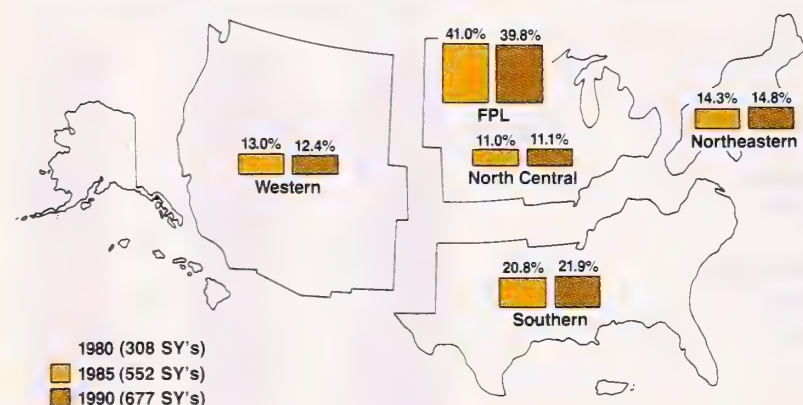
Forest protection research is focused on minimizing these losses. Increasingly, research is concentrating on preventive measures as well as control methods.

Research problem area	1980	1985	1990
	Scientist Years		
Control of insects affecting forests	146.6	204.6	258.1
Control of diseases, parasites, and nematodes affecting forests	83.0	128.6	153.9
Prevention and control of forest and range fires	90.9	118.7	142.9
Total	320.5	451.9	554.9

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL
Control of insects affecting forests						
	<ul style="list-style-type: none"> Develop improved silvicultural treatments to reduce impacts of insects on forest trees (integrated pest management programs). Improve techniques for monitoring insect populations and predicting major outbreaks and their impacts. Improve understanding of the dynamics of insect population. Develop insect control techniques, using environmentally safe pesticides and behavioral and microbial agents, both as sole treatments and as part of integrated pest management programs. Improve methods of reducing insect damage to wood products. Derive a better understanding of the pest/host/environmental interactions and find means for dealing with these situations. 	•	•	•	•	
		•	•	•	•	
		•	•	•		
		•	•	•	•	
		•	•	•	•	•
		•		•		
Control of diseases, parasites, and nematodes affecting forests						
	<ul style="list-style-type: none"> Reduce disease-caused mortality of tree seedlings, both in the nursery and field. Develop basic understanding of the biology of forest tree diseases, mycorrhizae, and parasites and their impacts. Improve capability to predict forest disease epidemics. Develop improved controls for forest diseases and parasites—both as controls and as part of integrated pest management programs. Determine the impact of air quality on wildland vegetation. Develop techniques for culturing and identifying slash and products — decaying fungi. Develop and evaluate biochemical control techniques for fungi that stain or degrade wood. 	•	•	•		
		•	•	•	•	•
		•	•	•	•	
		•	•	•	•	
		•	•		•	•
					•	•
Prevention and control of forest and range fires						
	<ul style="list-style-type: none"> Improve fire risk forecasting and devise fuel management methods. Improve understanding of fire behavior and improve fire control methods. Improve techniques for preventing fires. Improve prescribed burning techniques, both for use as a land management tool and for hazard reduction. Improve understanding of the effects of fire. Determine economics of fire prevention, management control, and hazard reduction. Improve techniques for reducing fuel hazards in all-aged and even-aged forests. 	•	•	•		
		•	•	•		
		•	•	•		
		•	•	•	•	
		•	•	•	•	
		•	•	•		
		•	•	•		

Percentage Distribution of Scientist Years (SY's)

Harvesting, Processing, and Marketing of Wood Products



Harvesting, Processing, and Marketing of Wood Products

Future requirements for timber-based materials can be met in part through better use of our wood resources. It is now physically possible to increase per-acre harvest of wood fiber 50 to 100 percent in many areas by removing defective logs, tops, and branches. Similarly, it is possible to increase substantially the yields of materials from logs and to improve greatly the efficiency of wood product use in buildings and manufactured goods. But research is needed to make these possibilities economically feasible.

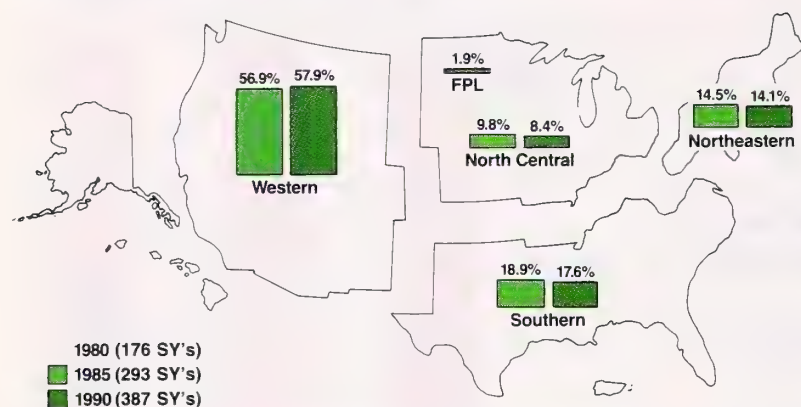
Research problem area	1980	1985	1990
Scientist Years			
Harvesting and forest engineering system	30.8	72.0	92.4
Properties, processing, and protection	227.6	410.2	497.0
Economics and marketing of wood products	50.1	70.3	88.1
Total	308.5	552.5	677.5

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL
Harvesting and forest engineering systems	• Develop improved road design and construction practices to reduce erosion and mass soil movement.	•			•	
	• Develop residue handling, harvesting and transportation systems that are cost effective and will reduce energy requirements and environmental damage.	•	•	•	•	
	• Develop methods to harvest logging residues for energy.	•	•	•	•	
	• Improve harvesting systems for logging on steep terrain and unstable slopes.	•	•		•	

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL
Properties, processing, and protection of wood	<ul style="list-style-type: none"> • Improve technology for economic use of small or low-value timber. 	•	•	•	•	•
	<ul style="list-style-type: none"> • Investigate fundamental factors in web consolidation and determine how new manufacturing techniques might affect the utility of paper and paperboard. 					•
	<ul style="list-style-type: none"> • Develop new and improved pulping methods. 					•
	<ul style="list-style-type: none"> • Develop new and improved methods of manufacturing paper and paper products. 					•
	<ul style="list-style-type: none"> • Identify and evaluate the opportunities for new and improved applications of paper and paperboard products. 					•
	<ul style="list-style-type: none"> • Develop better methods for recovery and use of chemicals from wood including integrated chemical/pulp production processes. 					•
	<ul style="list-style-type: none"> • Production of alcohol fuels from wood or development of improved direct combustion methods. 		•			•
	<ul style="list-style-type: none"> • Develop new and improved composite wood products along with supporting engineering information. 		•	•		•
	<ul style="list-style-type: none"> • Analyze structure and characteristics of emerging commercial species. 		•	•		•
	<ul style="list-style-type: none"> • Develop new and improved methods of protecting wood products in use including fire safety. 					•
	<ul style="list-style-type: none"> • Determine the basic physical and mechanical properties of wood and their relationship to performance. 		•			•
	<ul style="list-style-type: none"> • Evaluate the composite structural performance of wood products and develop new and improved structural assemblies and systems including improved acoustic/moisture/thermal environment. 					•
	<ul style="list-style-type: none"> • Develop new or improved wood processing technology. 		•	•	•	•
	<ul style="list-style-type: none"> • Devise methods to improve energy conservation in product manufacture. 	•				•
	<ul style="list-style-type: none"> • Improve our knowledge of timber preservation. 	•		•		•
	<ul style="list-style-type: none"> • Determine lumber grade recovery factors for major species. 	•				
	<ul style="list-style-type: none"> • Determine yields from harvest of standing dead and down timber. 	•			•	
	<ul style="list-style-type: none"> • Determine yield by log and tree quality classes. 	•			•	
Economics and marketing of forest products	<ul style="list-style-type: none"> • Analyze markets and potential markets for wood and fiber supplies. 	•	•		•	
	<ul style="list-style-type: none"> • Evaluate the economic feasibility of new timber production processes and products. 		•			•
	<ul style="list-style-type: none"> • Determine costs of new technologies in harvesting and milling forest products. 	•				
	<ul style="list-style-type: none"> • Investigate energy-efficient procedures in fuelwood harvesting. 	•				
	<ul style="list-style-type: none"> • Analyze and evaluate U.S. and international timber markets. 	•		•		•
	<ul style="list-style-type: none"> • Improve techniques for price forecasting at regional and local levels. 	•				

Percentage Distribution of Scientist Years (SY's)

Forest Watersheds, Soils, and Pollution



Forest Watersheds, Soils, and Pollution

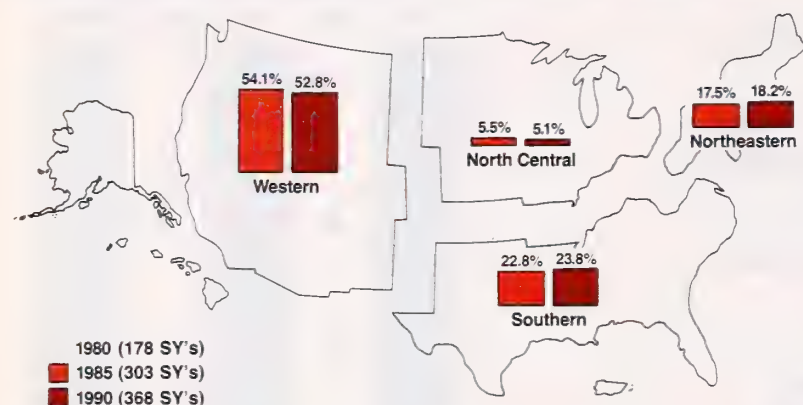
Forests and rangelands are the source of two-thirds of America's high-quality water. These watersheds also produce timber, forage for domestic livestock, habitat and food for wildlife, and recreational opportunities for people. All these uses influence water quality and yields; soil properties; site productivity for timber, forage, and wildlife; air quality; and quality of land for recreation. Because these influences promise to become greater as intensity of forest management increases, research must develop ways to minimize their impact on air, soil, and water quality.

Research problem area	1980	1985	1990
Scientist Years			
Watershed protection and management	121.6	190.2	243.5
Soil, plant, water, and nutrient relationships	25.8	41.9	55.0
Alleviation of soil, water, and air pollution	28.9	61.1	88.1
Total	176.3	293.2	386.6

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL
Watershed protection and management						
	<ul style="list-style-type: none"> Determine impacts of land management and engineering practices on soil erosion, water yield and quality, and fish and wildlife habitat. Improve methods for predicting soil erosion and mass soil movement. Develop better techniques for managing and rehabilitating mining and oil extraction areas. Develop and improve snow management practices. Identify water quality and quantity tradeoffs under alternative forest management practices. Investigate hydrology, erosion, and water quality on western range watersheds. Determine the impact of pest management practices. Determine the effect of acid rain on growth and yield of forest stands. Improve conservation of prime agricultural land. Determine the correlation between land ownership, size, and forest production use. 	• • • • • •	• • • •	• •	• • • • • •	
Soil, plant, water, and nutrient relationships						
	<ul style="list-style-type: none"> Determine effects of timber management practices on water yield and quality. Determine the effect of site preparation methods on soil properties and productivity. Provide information on nutrient cycling relationships associated with intensive forest management practices. Determine the effect of full-tree utilization on soil properties, tree growth rates and physiology in succeeding rotations. Determine the effects of different site-preparation practices on soil physical properties, nutrient reserves, biota, and long-term productivity. Define the impact of heavy woods equipment on soils, and determine how to best avoid damage. 	• • • •	• •	• • • •	• •	
Alleviation of soil, water, and air pollution						
	<ul style="list-style-type: none"> Develop technology to alleviate pollution from disturbed sites. Develop methods for rehabilitating disturbed lands. Develop information on hazardous wastes from mining operations. Determine the effect of acid rain on trees. Determine the effect of point and nonpoint pollution on trees. Determine the effects of wildland burning on air quality. 	• • • •	• • •	• • • • •	• •	

Percentage Distribution of Scientist Years (SY's)

Forest Range, Wildlife, and Fisheries Habitat Development



Forest Range, Wildlife, and Fisheries Habitat Development

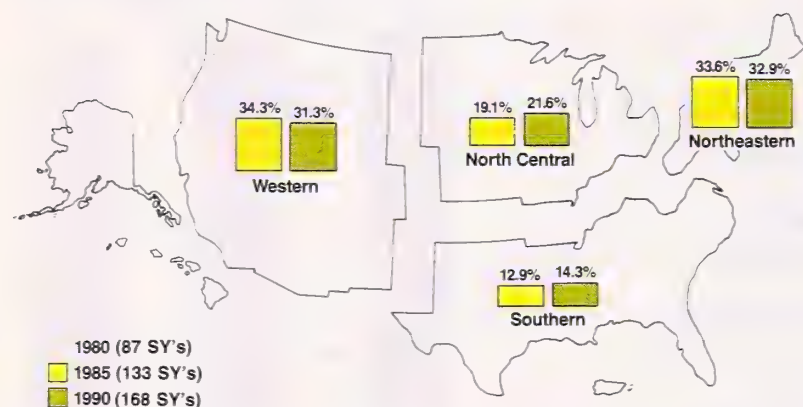
Eighteen percent (159 million acres) of the Nation's 883 million acres of rangeland are in poor condition. Much of these lands are arid and semi-arid. They produce less than 40 percent of their potential due to poor soil and vegetation condition. Forest range and associated rangelands, in addition to producing forage for livestock, provide valuable habitat for wildlife, serve as watersheds, and provide open space and natural beauty that is enjoyed by increasing numbers of recreationists. Research is needed to develop integrated management plans that maintain or enhance productivity and value of rangeland forage and related resources.

Forests and their waters are an important habitat for many kinds of wildlife and fish. They must be managed to benefit both game and nongame species, with particular attention to endangered species. While past research has developed some guidelines for tailoring forest and range management practices to the needs of certain wildlife and fish, especially game species, the need now is to develop more refined information that is more widely applicable to all vertebrate species and to a greater variety of habitats.

Research problem area	1980	1985	1990
Scientist Years			
Management of range resources	42.7	76.3	86.8
Wildlife and fish habitat	135.2	226.3	281.2
Total	177.9	302.6	368.0

Research problem area	Types of studies	Regions where studies would be emphasized				
		W	NC	S	NE	FPL
Management of range resources	• Develop improved forage plants and establishment methodology.	•				
	• Develop livestock management practices that will maximize meat and fiber production while minimizing environmental damage.	•		•		
	• Integrate range management with other land management practices.	•	•	•		
	• Improve rangeland cultural practices.	•		•		
	• Improve methods for estimating forage production and carrying capacities.	•		•		
	• Determine animal foraging preferences and develop strategies for integrated forage and habitat by livestock and wildlife.	•		•		
	• Improve understanding of rangeland ecology, including trees and endangered species.	•		•		
	• Improve rangeland productivity through the use of prescribed fire.	•				
Wildlife and fish habitat	• Identify and quantify habitat requirements.	•	•	•	•	
	• Evaluate impacts of land use on wildlife and fish.	•	•	•	•	
	• Develop and improve habitats.	•	•	•	•	
	• Improve wildlife habitat management in rapidly urbanizing areas.	•				
	• Understand the economic impacts of wilderness classifications and the rationality of wilderness designation to fish and wildlife management.	•				
	• Understand the habitat requirements of nongame animals, forest birds, and fish.	•	•	•		

Forest Recreation and Environmental Values



Trees and forests provide a variety of amenity or noncommodity values that are steadily assuming greater significance to Americans. The goal of research in this area is to enhance these values and experiences and widen their availability in both rural and urban areas, and to assist in the coordinated development of both the commercial and public segments of the outdoor recreation market.

Research problem area	1980	1985	1990
	Scientist Years		
Outdoor recreation	56.6	93.6	113.7
Rural and urban environmental enhancement	30.2	39.8	53.9
Total	86.8	133.4	167.6

Research problem area	Types of studies	Regions where studies would be emphasize				
		W	NC	S	NE	FPL
Outdoor recreation						
	<ul style="list-style-type: none"> Determine demand for various types of outdoor recreation experiences. Improve recreation and landscape management strategies. Develop wilderness recreation management strategies. Measure the effects on archeological, cultural, and historical sites by various land management activities. Establish methods for determining recreational carrying capacity of wilderness areas. Measure the effect of energy costs and availability on potential use of recreation areas. Determine limnology of constructed water impoundments and the cause of algae blooms and fish kill. 	●	●	●	●	
		●			●	
		●	●	●	●	
		●				
		●			●	
		●		●		
		●				
Rural and Urban Environment Enhancement						
	<ul style="list-style-type: none"> Develop improved methods to manage urban forest resources. Design ways to integrate urban forest planning with urban development planning. Investigate urban forestry problems, including the testing of tree species unique to arid lands. 	●	●	●	●	
		●	●		●	
		●			●	

Appendix

National

Scientist Years (SY's) for Forestry and Associated Rangelands Research for the State Agricultural Experiment Stations and Forestry Schools (SAES & F.Sch.), and USDA Forest Service (USDA-F.Serv.) for 1980, 1985, 1990.

Research Program and Research Problem Area	1980			1985			1990		
	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total
Scientist Years									
Multiresource Inventory									
Appraisal	33.5	65.7	99.2	55.0	149.9	204.9	76.3	181.0	257.3
Alternative Uses	12.2	1.2	13.4	19.5	6.0	25.5	26.8	5.0	31.8
Evaluation	21.8	32.0	53.8	32.9	71.8	104.7	43.8	90.8	134.6
Subtotal	67.5	98.9	166.4	107.4	227.7	335.1	146.9	276.8	423.7
Timber Management									
Biology	118.0	176.9	294.9	157.2	270.2	427.4	196.5	310.4	506.9
Genetics	36.0	36.9	72.9	50.0	51.7	101.7	63.8	62.4	126.2
Economics	20.5	15.8	36.3	33.4	15.6	49.0	46.2	19.2	65.4
Subtotal	174.5	229.6	404.1	240.6	337.5	578.1	306.5	392.0	698.5
Forest Protection									
Insects	34.1	112.5	146.6	45.8	158.8	204.6	57.5	200.6	258.1
Diseases	24.2	58.8	83.0	32.0	96.6	128.6	39.7	114.2	153.9
Fires	4.8	86.1	90.9	6.8	111.9	118.7	8.7	134.2	142.9
Subtotal	63.1	257.4	320.5	84.6	367.3	451.9	105.9	449.0	554.9
Harvesting, Processing, & Wood Products									
Harvesting	10.8	20.0	30.8	19.0	53.0	72.0	27.4	65.0	92.4
Properties, Processing, & Protection	95.3	132.3	227.6	126.9	283.3	410.2	158.2	338.8	497.0
Marketing	13.5	36.6	50.1	21.7	48.6	70.3	29.9	58.2	88.1
Subtotal	119.6	188.9	308.5	167.6	384.9	552.5	215.5	462.0	677.5
Watersheds, Soils, & Pollution									
Watersheds	26.3	95.3	121.6	39.3	150.9	190.2	52.7	190.8	243.5
Soils	24.6	1.2	25.8	37.9	4.0	41.9	51.0	4.0	55.0
Pollution	18.9	10.0	28.9	26.4	34.7	61.1	33.7	54.4	88.1
Subtotal	69.8	106.5	176.3	103.6	189.6	293.2	137.4	249.2	386.6
Range, Wildlife, & Fisheries Habitat									
Range	28.4	14.3	42.7	38.4	37.9	76.3	48.2	38.6	86.8
Wildlife	73.7	61.5	135.2	99.7	126.6	226.3	125.8	155.4	281.2
Subtotal	102.1	75.8	177.9	138.1	164.5	302.6	174.0	194.0	368.0
Recreation & Environmental Values									
Recreation	35.5	21.1	56.6	47.0	46.6	93.6	58.4	55.3	113.7
Environment	25.0	5.2	30.2	33.7	6.1	39.8	42.4	11.5	53.9
Subtotal	60.5	26.3	86.8	80.7	52.7	133.4	100.8	66.8	167.6
Total	657.1	983.4	1,640.5	922.6	1,724.2	2,646.8	1,187.0	2,089.8	3,276.8

Western Region

Scientist Years (SY's) for Forestry and Associated Rangelands Research for the State Agricultural Experiment Stations and Forestry Schools (SAES & F.Sch.), and USDA Forest Service (USDA-F.Serv.) for 1980, 1985, 1990.

Research Program and Research Problem Area	1980			1985			1990		
	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total
Scientist Years									
Multiresource Inventory									
Appraisal	7.8	29.6	37.4	12.7	73.4	86.1	17.6	87.5	105.1
Alternative Uses	5.7	0.0	5.7	9.8	0.0	9.8	13.9	0.0	13.9
Evaluation	5.2	14.5	19.7	7.9	46.0	53.9	10.5	52.3	62.8
Subtotal	18.7	44.1	62.8	30.4	119.4	149.8	42.0	139.8	181.8
Timber Management									
Biology	28.8	54.5	83.3	37.5	91.6	129.1	46.3	107.4	153.7
Genetics	5.6	12.8	18.4	8.9	16.0	24.9	12.1	21.9	34.0
Economics	4.5	4.0	8.5	6.5	2.0	8.5	8.5	2.5	11.0
Subtotal	38.9	71.3	110.2	52.9	109.6	162.5	66.9	131.8	198.7
Forest Protection									
Insects	7.5	44.6	52.1	9.8	70.1	79.9	12.0	91.5	103.5
Diseases	3.0	19.2	22.2	4.3	25.0	29.3	5.6	27.4	33.0
Fires	3.7	63.1	66.8	5.0	80.9	85.9	6.3	92.2	98.5
Subtotal	14.2	126.9	141.1	19.1	176.0	195.1	23.9	211.1	235.0
Harvesting, Processing, & Wood Products									
Harvesting	2.2	6.0	8.2	3.4	20.8	24.2	4.7	25.2	29.9
Properties, Processing, & Protection	23.7	7.0	30.7	28.7	13.0	41.7	33.5	13.1	46.6
Marketing	2.5	3.0	5.5	3.7	2.0	5.7	4.9	2.8	7.7
Subtotal	28.4	16.0	44.4	35.8	35.8	71.6	43.1	41.1	84.2
Watersheds, Soils, & Pollution									
Watersheds	11.4	65.4	76.8	17.5	112.3	129.8	23.7	146.0	169.7
Soils	7.6	1.2	8.8	12.8	4.0	16.8	17.9	4.0	21.9
Pollution	3.4	3.1	6.5	5.6	14.5	20.1	7.8	24.4	32.2
Subtotal	22.4	69.7	92.1	35.9	130.8	166.7	49.4	174.4	223.8
Range, Wildlife, & Fisheries Habitat									
Range	27.3	12.8	40.1	36.7	34.3	71.0	46.1	32.3	78.4
Wildlife	15.4	37.7	53.1	20.0	72.7	92.7	24.6	91.5	116.1
Subtotal	42.7	50.5	93.2	56.7	107.0	163.7	70.7	123.8	194.5
Recreation & Environmental Values									
Recreation	15.3	8.1	23.4	19.7	21.6	41.3	24.1	23.3	47.4
Environment	3.9	0.0	3.9	4.5	0.0	4.5	5.0	0.0	5.0
Subtotal	19.2	8.1	27.3	24.2	21.6	45.8	29.1	23.3	52.4
Total	184.5	386.6	571.1	255.0	700.2	955.2	325.1	845.3	1170.4

North Central Region

Scientist Years (SY's) for Forestry and Associated Rangelands Research for the State Agricultural Experiment Stations and Forestry Schools (SAES & F.Sch.), and USDA Forest Service (USDA-F.Serv.) for 1980, 1985, 1990.

Research Program and Research Problem Area	1980			1985			1990		
	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total
Scientist Years									
Multiresource Inventory									
Appraisal	7.5	8.0	15.5	12.5	18.0	30.5	17.5	21.0	38.5
Alternative Uses	2.3	1.2	3.5	3.5	6.0	9.5	4.6	5.0	9.6
Evaluation	1.0	5.6	6.6	3.1	8.0	11.1	5.2	16.0	21.2
Subtotal	10.8	14.8	25.6	19.1	32.0	51.1	27.3	42.0	69.3
Timber Management									
Biology	26.3	32.2	58.5	34.3	53.0	87.3	42.3	54.0	96.3
Genetics	9.4	6.0	15.4	12.2	9.0	21.2	14.9	11.0	25.9
Economics	3.6	1.8	5.4	7.2	2.0	9.2	10.7	2.0	12.7
Subtotal	39.3	40.0	79.3	53.6	64.0	117.6	67.9	67.0	134.9
Forest Protection									
Insects	4.5	17.5	22.0	6.0	23.5	29.5	7.6	27.5	35.1
Diseases	4.1	10.1	14.2	4.9	21.5	26.4	5.7	24.5	30.2
Fires	0.4	5.0	5.4	0.5	14.0	14.5	0.5	19.0	19.5
Subtotal	9.0	32.6	41.6	11.4	59.0	70.4	13.8	71.0	84.8
Harvesting, Processing, & Wood Products									
Harvesting	2.2	5.7	7.9	3.7	14.0	17.7	5.2	17.0	22.2
Properties, Processing, & Protection	15.5	4.0	19.5	19.8	10.0	29.8	24.0	12.0	36.0
Marketing	3.3	5.3	8.6	5.1	8.0	13.1	6.8	10.0	16.8
Subtotal	21.0	15.0	36.0	28.5	32.0	60.5	36.0	39.0	75.0
Watersheds, Soils, & Pollution									
Watersheds	4.6	3.2	7.8	6.8	6.0	12.8	9.1	5.0	14.1
Soils	2.8	0.0	2.8	4.7	0.0	4.7	6.6	0.0	6.6
Pollution	4.2	3.7	7.9	5.1	6.0	11.1	5.9	6.0	11.9
Subtotal	11.6	6.9	18.5	16.6	12.0	28.6	21.6	11.0	32.6
Range, Wildlife, & Fisheries Habitat									
Range	0.0	0.0	0.0	0.2	0.0	0.2	0.3	0.0	0.3
Wildlife	5.2	9.5	14.7	7.1	9.5	16.6	9.0	9.5	18.5
Subtotal	5.2	9.5	14.7	7.3	9.5	16.8	9.3	9.5	18.8
Recreation & Environmental Values									
Recreation	5.7	6.0	11.7	7.2	10.0	17.2	8.6	12.0	20.6
Environment	4.4	3.5	7.9	6.2	2.1	8.3	8.1	7.5	15.6
Subtotal	10.1	9.5	19.6	13.4	12.1	25.5	16.7	19.5	36.2
Total	107.0	128.3	235.3	149.9	220.6	370.5	192.6	259.0	451.6

Southern Region

Scientist Years (SY's) for Forestry and Associated Rangelands Research for the State Agricultural Experiment Stations and Forestry Schools (SAES & F.Sch.), and USDA Forest Service (USDA-F.Serv.) for 1980, 1985, 1990.

Research Program and Research Problem Area	1980			1985			1990		
	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total
Scientist Years									
Multiresource Inventory									
Appraisal	11.3	16.0	27.3	20.1	44.5	64.6	28.8	55.5	84.3
Alternative Uses	0.6	0.0	0.6	1.2	0.0	1.2	1.8	0.0	1.8
Evaluation	2.7	7.5	10.2	3.8	10.8	14.6	4.9	14.5	19.4
Subtotal	14.6	23.5	38.1	25.1	55.3	80.4	35.5	70.0	105.5
Timber Management									
Biology	43.8	63.2	107.0	58.7	91.6	150.3	73.5	110.5	184.0
Genetics	15.7	13.0	28.7	21.5	20.7	42.2	27.3	24.5	51.8
Economics	10.9	10.0	20.9	17.6	11.6	29.2	24.3	14.7	39.0
Subtotal	70.4	86.2	156.6	97.8	123.9	221.7	125.1	149.7	274.8
Forest Protection									
Insects	7.7	38.6	46.3	9.8	49.2	59.0	11.9	66.6	78.5
Diseases	7.3	13.4	20.7	9.1	27.6	36.7	10.8	35.2	46.0
Fires	0.7	18.0	18.7	1.3	17.0	18.3	1.9	23.0	24.9
Subtotal	15.7	70.0	85.7	20.2	93.8	114.0	24.6	124.8	149.4
Harvesting, Processing, & Wood Products									
Harvesting	4.8	3.5	8.3	9.7	12.2	21.9	14.6	14.8	29.4
Properties, Processing, & Protection	32.5	24.0	56.5	45.4	39.0	84.4	58.3	48.0	106.3
Marketing	4.6	0.0	4.6	8.6	0.0	8.6	12.6	0.0	12.6
Subtotal	41.9	27.5	69.4	63.7	51.2	114.9	85.5	62.8	148.3
Watersheds, Soils, & Pollution									
Watersheds	5.9	17.3	23.2	8.9	21.1	30.0	11.9	25.3	37.2
Soils	7.4	0.0	7.4	10.9	0.0	10.9	14.3	0.0	14.3
Pollution	1.4	2.4	3.8	1.8	12.7	14.5	2.2	14.5	16.7
Subtotal	14.7	19.7	34.4	21.6	33.8	55.4	28.4	39.8	68.2
Range, Wildlife, & Fisheries Habitat									
Range	1.1	1.5	2.6	1.5	3.6	5.1	1.8	6.3	8.1
Wildlife	23.1	11.2	34.3	30.6	33.4	64.0	38.2	41.4	79.6
Subtotal	24.2	12.7	36.9	32.1	37.0	69.1	40.0	47.7	87.7
Recreation & Environmental Values									
Recreation	4.2	4.0	8.2	5.7	10.0	15.7	7.1	13.0	20.1
Environment	1.4	0.0	1.4	1.6	0.0	1.6	1.8	2.0	3.8
Subtotal	5.6	4.0	9.6	7.3	10.0	17.3	8.9	15.0	23.9
Total	187.1	243.6	430.7	267.8	405.0	672.8	348.0	509.8	857.8

Northeastern Region

Scientist Years (SY's) for Forestry and Associated Rangelands Research for the State Agricultural Experiment Stations and Forestry Schools (SAES & F.Sch.), and USDA Forest Service (USDA-F.Serv.) for 1980, 1985, 1990.

Research Program and Research Problem Area	1980			1985			1990		
	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total	SAES & F. Sch.	USDA- F. Serv.	Total
Scientist Years									
Multiresource Inventory									
Appraisal	6.9	12.1	19.0	9.7	14.0	23.7	12.4	17.0	29.4
Alternative Uses	3.6	0.0	3.6	5.0	0.0	5.0	6.5	0.0	6.5
Evaluation	12.9	4.4	17.3	18.1	7.0	25.1	23.2	8.0	31.2
Subtotal	23.4	16.5	39.9	32.8	21.0	53.8	42.1	25.0	67.1
Timber Management									
Biology	19.1	27.0	46.1	26.7	34.0	60.7	34.4	38.5	72.9
Genetics	5.3	5.1	10.4	7.4	6.0	13.4	9.5	5.0	14.5
Economics	1.5	0.0	1.5	2.1	0.0	2.1	2.7	0.0	2.7
Subtotal	25.9	32.1	58.0	36.3	40.0	76.3	46.6	43.5	90.1
Forest Protection									
Insects	14.4	10.8	25.2	20.2	14.0	34.2	26.0	14.0	40.0
Diseases	9.8	9.3	19.1	13.7	10.0	23.7	17.6	10.5	28.1
Fires	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	24.2	20.1	44.3	33.9	24.0	57.9	43.6	24.5	68.1
Harvesting, Processing, & Wood Products									
Harvesting	1.6	4.8	6.4	2.2	6.0	8.2	2.9	8.0	10.9
Properties, Processing, & Protection	23.6	8.1	31.7	33.0	8.0	41.0	42.4	11.0	53.4
Marketing	3.1	20.3	23.4	4.3	25.5	29.8	5.6	30.5	36.1
Subtotal	28.3	33.2	61.5	39.6	39.5	79.1	50.9	49.5	100.4
Watersheds, Soils, & Pollution									
Watersheds	4.4	9.4	13.8	6.1	11.5	17.6	8.0	14.5	22.5
Soils	6.8	0.0	6.8	9.5	0.0	9.5	12.2	0.0	12.2
Pollution	9.9	0.8	10.7	13.9	1.5	15.4	17.8	2.0	19.8
Subtotal	21.1	10.2	31.3	29.5	13.0	42.5	38.0	16.5	54.5
Range, Wildlife, & Fisheries Habitat									
Range	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wildlife	30.0	3.1	33.1	42.0	11.0	53.0	54.0	13.0	67.0
Subtotal	30.0	3.1	33.1	42.0	11.0	53.0	54.0	13.0	67.0
Recreation & Environmental Values									
Recreation	10.3	3.0	13.3	14.4	5.0	19.4	18.6	7.0	25.6
Environment	15.3	1.7	17.0	21.4	4.0	25.4	27.5	2.0	29.5
Subtotal	25.6	4.7	30.3	35.8	9.0	44.8	46.1	9.0	55.0
Total	178.5	119.9	298.4	249.9	157.5	407.4	321.3	181.0	502.3

Forest Products Laboratory

Scientist Years (SY's) for Forestry and Associated
Rangelands Research for 1980, 1985, and 1990.

Research Program and Research Problem Areas	1980 USDA F.Serv.	1985 USDA F.Serv.	1990 USDA F.Serv.
Scientist Years			
Multiresource Inventory			
Appraisal	0.0	0.0	0.0
Alternative Uses	0.0	0.0	0.0
Evaluation	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0
Timber Management			
Biology	0.0	0.0	0.0
Genetics	0.0	0.0	0.0
Economics	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0
Forest Protection			
Insects	1.0	2.0	1.0
Diseases	6.8	12.5	16.6
Fires	0.0	0.0	0.0
Subtotal	7.8	14.5	17.6
Harvesting, Processing, & Wood Products			
Harvesting	0.0	0.0	0.0
Properties, Process- ing, & Protection	89.2	213.3	254.7
Marketing	8.0	13.1	14.9
Subtotal	97.2	226.4	269.6
Watersheds, Soils, & Pollution			
Watersheds	0.0	0.0	0.0
Soils	0.0	0.0	0.0
Pollution	0.0	0.0	7.5
Subtotal	0.0	0.0	7.5
Range, Wildlife, & Fisheries Habitat			
Range	0.0	0.0	0.0
Wildlife	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0
Recreation & Environmental Values			
Recreation	0.0	0.0	0.0
Environment	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0
TOTAL	105.0	240.9	294.7

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